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Municipal Lighting. THE Commonwealth of Massachusetts has now legalized the municipal ownership of gas and electric lighting plants. We presume that this action will produce a renewal of the much vexed question as to the economy of such public installations, as well as a considerable number of examples of practice furnishing evidence for both sides of the question. It is a pretty close approximation to the truth to say that although municipal plants can be economically conducted, they generally are not. Occasionally there will be found a town where the desires of the representative political parties are merged in a common effort for the public good—localities in which the much abused mugwump has become sufficiently numerous to exercise a controlling influence. Under such circumstances a municipal installation may be and very likely will be conducted economically, but it is only too obvious that the necessary conditions do not exist as frequently as might be desired.

The Incandescent Lamp Suit. WE publish this week a synopsis of the opening argument for the complainant in the great incandescent lamp case, as well as some further discussion of the general aspects of the question. It is not often that we have occasion to go so fully into details of a lawsuit, but the importance of the present one seems to warrant somewhat extended discussion. Not only is the incandescent lamp patent one of great intrinsic value, but the case is rendered of unique importance by the enormous amount of capital involved. In the telephone cases up to the present the most important patent suits brought against the infringers were quickly brought into court and injunctions obtained without waiting for further development of the business. In the incandescent lamp suit, however, the main case is not argued until more than a decade has elapsed since the issuing of the patent. Alleged infringers have been permitted to go on without active measures being taken against them until their business has assumed colossal dimensions. Probably not less than $50,000,000 capital are invested in the various companies whose commercial success is involved. The complainant is the Edison company with $12,000,000 capital, and with the interests of the real defendant, the Westinghouse company, with some $7,000,000 capital, are bound up those of the Thomson-Houston company, which also makes its own lamps and whose capital stock to-day has a market value of nearly $20,000,000. Aside from this, a number of other companies make incandescent lamps, and the power of all of them to compete with the Edison company on favorable terms is involved in the present suit. It is this feature of the case that gives it its commanding importance. We have, therefore, thought it best to discuss the situation fully and freely.

The Ground Return Question. ONE of the interesting decisions recently promulgated by the courts, is that in the appealed case of the Cincinnati Inclined Plane Railway Company vs. the telephone interests of that city. It will be remembered that in the original suit the telephone was the winner, and the right of electric railway companies to use the single trolley system was very seriously called in question. In short, the telephone companies, with their customary modesty, claimed the earth by virtue of prior occupation. The present decision, however, on appeal, reverses the finding of the lower court, holding that the prime object of streets is for facilitating public travel and not for the convenience of the licensees of the American Bell Telephone Company, and therefore it is held that any means of improving the use of the streets for their original purpose should take precedence over other interests concerned. There is no doubt that the single trolley system is oftentimes very inconvenient for neighboring telephones, and many a subscriber has heaped objurgations on the electric road for the indescribable whirring and buzzing that has greeted his ears when he has attempted conversation. To a certain extentt he grounded trolley wire is therefore unpopular, but if the result of the establishment of its legal rights shall be to encourage the use of double metallic circuits, the public will have much to be grateful for. The superiority of such a service is too well known to need comment here, and the telephone companies undoubtedly appreciate the fact as well as the subscribers. In a number of places they are making laudable efforts to introduce it as far as possible, but the decision that we are mentioning will serve as a stimulus in cases where ordinary protests are of no avail.

The Kinetograph. MR. EDISON never seems to be truly happy unless he is devising some mechanism of extraordinary ingenuity, and the latest product of his efforts in this direction is the kinetograph, brief notices of which have recently appeared in the metropolitan papers. The kinetograph is the lineal descendant of the old zoëtrope and Prof. Muybridge's instantaneous photographs of animals in motion. These comparatively simple and unpretentious things have been glorified in Mr. Edison's hands into an apparatus for the purpose of continuously recording motion and reproducing it at will. The mechanism is still undergoing improvement, but a fairly good idea of it may be had in the following way: Imagine a Kodak with the film cylinder and drop shutter adapted to be operated by an electric motor exposing 30 to 40 pictures a second if necessary; turn such an instrument loose, for example, on an acrobat, taking a continuous string of pictures of him at the rate mentioned until the film gives out. Then develop and prepare just as a lantern slide is prepared, put a projecting lens like that of a magic lantern in place of the photographic lens of the camera, and then by means of a powerful light project the images of the photographs upon a screen, run the driving mechanism and whisk the pictures by the projecting lens. The result will be a very clear reproduction of the original motions that were photographed, life size. Of course it is not necessary to project the pictures, except for the edification of a large audience; in private the motions can be viewed with the eye when proper illumination is given the pictures. The inventor proposes to keep a continuous record of a public speaker's motions on the kinetograph exactly as he would record the spoken words in the phonograph, and reproduce the two together for the amusement of future generations. The device of applying instantaneous photography to the zoëtrope, or of projecting the rapidly shifting pictures on a screen, is not at all new, Professor Muybridge having used it in his lectures some years ago; but never has any one attempted the continuous record of motion on anything like so colossal a scale, and the new instrument cannot fail to be a popular source of amusement for a time, even if nothing of more serious importance comes of it.

Genuine Common Sense. IN conversation with a telephone manager the other day we received an agreeable surprise by hearing him say after telling of some serious damage that had been done by an encounter with a trolley wire: "Well, it was our fault, for our lines fell over their wire." This was a lesson in common sense and civilized charity that may be well taken to heart by others. There is no reason why electrical interests in a given town should ever come into collision unless in the way of direct competition. When an accident like that which produced the above remark happens, electric railway managers do not rub their hands in glee at the damage that has been done. On the contrary, they are usually very sorry for it, and are quite willing to take any reasonable precaution to prevent its recurrence. Nor is it a source of delight to get a ground that drops all the shutters in the telephone exchange. In most cities these interests, each in its way necessary to the public convenience, are in thorough harmony, and with a little care on both sides they should continue to be so. Sometimes a very little concession on the part of either will avert a considerable amount of annoyance, and the sooner both parties learn to exercise a spirit of friendly forbearance the better it will be for both and the public which they mutually serve. As we mention elsewhere in these columns, the legal rights in the case seem to be at present rather in favor of the electric railway companies, but this is all the more reason that they should exercise a good deal of care and be ready to meet their neighbors at least half way in averting difficulties. There are moral obligations in this world as well as legal ones, and one of the chief of these is to so carry on one's business as to cause the minimum amount of trouble to others.

A New Alternating Current Motor System. ON another page we take pleasure in presenting a communication from Mr. William Stanley, Jr., and his collaborateur, Mr. Kelly, relating to a new form of alternating motors with which the authors have been experimenting. The paper was received from Mr. Stanley, with a note, under date of May 15, and was held until the present, pending certain complications relating to patents. The method employed is a very beautiful one from a theoretical standpoint, and certainly promises practical results of some value. It consists in preventing any appreciable difference of phase between the magnetization of the field and the armature of the motor, by inserting sufficient capacity to compensate for the self-induction that would produce a difference of phase; in other words, a condenser is inserted in series with the circuit so that the electromotive force given by the condenser will be equal in value to, and 180 degrees distant in phase from, the electromotive force of self-induction. There will then be upon the circuit three electromotive forces: First, that impressed; second, that of self-induction in quadrature of the first and lagging behind it; third, that of the condenser, also in quadrature and in advance of the impressed electromotive force. The motor actually employed in this work is an ordinary two-pole machine, and the authors have succeeded in thus balancing the circuits sufficiently well to develop the magnetization and operate the motor as if it were supplied with direct currents, barring the effects of hysteresis and the like. It is obvious that for any particular motor and magnetic condition of that motor a special capacity is required in order to produce the condition of neutralizing the difference in phase. A motor constructed on this principle, then, will depend for its satisfactory operation on sensibly constant coefficients of self-induction and mutual induction between the parts. How far this symmetry can be preserved is a question of no small importance, for on it depends the usefulness of the device on a large scale. For small work with comparatively uniform loads no difficulty whatever ought to be experienced; but for extensive applications a special type of motor, possessing in so far as possible the property of uniform self and mutual inductions, will be necessary. Without it difficulty would certainly be met. Further, in any and every attempt at magnetization by alternating currents, hysteresis is encountered and cannot be escaped. Its effect can be lessened by a proper choice of iron, but not eliminated, and therefore the working efficiency of a motor like that proposed will be somewhat reduced by hysteresis in the field. This is not, however, a very serious objection for many purposes where power is desired. The alternate current motor has as yet had a very small chance to show its real qualities, and we trust that Mr. Stanley's new machine may make the sight of such more familiar than it is at present to most of our readers. The series wound direct current motor has been tried before on alternating currents, but the difficulty of difference of phase and inability to start readily has made it inapplicable, aside from any question of efficiency. In passing, it may be worth mentioning that the same principle used in the alternating motor has been found by the authors to be very convenient for suppressing induction and leakage currents in telephone circuits, a use that of itself is of no small importance.

Latest Foreign Electrical News.

(By cable from our regular correspondent.)

LONDON, June 8, 1891.—The result of the Paris meter competition that has been in progress for nearly a year past is at last, after much delay, announced. The result is the assignment of two first and two second prizes, the first of five thousand francs each going to the Aron and to the Thomson wattmeter. The Aron meter has long been a favorite on the Continent, and consists, as will be remembered, of two clocks moving in unison except as one of them is retarded by a solenoid excited by the current to be measured. The difference in motion of the two clocks is registered on dials by the ordinary mechanism for such purpose. An attempt was made to introduce the Aron meter in America a year or two ago, but it met with little success and much opposition from the principal companies, and the agency was withdrawn. The Thomson wattmeter is too well known to Americans to require description; it is sufficient to say that it is a very well-arranged motor form of meter. The two second prizes went to the Frager and Maries meters respectively; these are not well known in either England or America, and are somewhat more complicated than their more successful competitors.

Mr. Crompton's report recommending the Glasgow municipality to adopt the low-tension system of distribution has been the subject of a great deal of adverse comment. The gas journals in speaking of this subject make a very unique suggestion—the operation of small sub-stations by gas engines. It is suggested that these be used to furnish the electricity to individual blocks.

The centenary of Faraday's birthday will be celebrated by the Royal Society on the 17th and 26th of this month by two lectures, to be given respectively by Lord Rayleigh and Prof. Dewar. The Prince of Wales is expected to attend this special celebration in honor of the foremost investigator of the century.

The electric launch has appeared on the Continent, one having recently been placed in operation on Lake Zurich. The coming summer will probably see a considerable addition to the number of these craft.

NEW BOOKS.

DECORATIVE ELECTRICITY. By Mrs. J. E. H. Gordon. Pp. 178; 36 illustrations. London: Sampson Low, Marston, Searle & Rivington, 1891. Price $3.75.

It is not often that one can say of an electrical book that it is thoroughly interesting reading and comment favorably on its literary merits, but the little treatise on artistic lighting that Mrs. Gordon, wife of the well known engineer, has just completed, is certainly one of the most readable and entertaining volumes we have had the pleasure of seeing in some time. It is simply a clever, chatty discussion of the best ways of lighting a house, not from the standpoint of the architect, who grimly allots so many candle power to each room, but in the interest of the people who are going to live in the house and desire to arrange the lighting for their personal comfort and convenience. Electric lighting, so far as residences are concerned, has suffered bitterly from the causes that Mrs. Gordon neatly suggests in the very first chapter of her book. Nothing can redeem the hideous ugliness of many modern electric light fixtures; carefully designed they are, neatly finished, elegant in form and beautifully polished, but, nevertheless, intensely philistine. The gas fixture had very few artistic possibilities, and it has in its departure left a legacy of ugliness that is not easily gotten rid of. Fortunately this is changed somewhat for the better at present, and one occasionally sees beaten iron or bronze fixtures that are really beautiful in design and thoroughly ornamental in their relations with the other interior decorations. Any one who intends to utilize incandescent lights in the household certainly should read and, more than that, study this little book, for it is filled with suggestions that will go far toward transforming the glaring illumination and shining brass too frequently found into the softened and artistic effects that can be obtained if one throws aside the conventional methods. One point worth thinking about, too, is the use of lamps of comparatively small candle power; the possibilities of these are barely recognized in this country, regardless of the fact that in very many cases an 8 or 10 c. p. lamp is every bit as serviceable as one of the ordinary size, consumes less current, and is far more useful artistically. As a practical ending to her charming book, Mrs. Gordon makes the statement that in her own home the bills for three consecutive quarters from April to the end of December were less than the cost of gas, oil and candles for the corresponding period of the previous year in a smaller house.

A New Electric Boat.

Mr. H. B. Collins, of Fulton, N. Y., has designed and built a small boat, which he has fitted up with storage batteries and an electric motor, also constructed by himself. The boat is 19 feet long with four-foot beam, and is intended to carry from four to six persons, although it has been made to carry ten at one time. It is fitted with 20 storage cells, each of which weighs about 50 pounds, the entire battery giving an electromotive force of 40 volts. The motor is about 3 h. p., although the average amount used in actual service is about 1½ h. p. The armature makes 2,100 revolutions per minute when the boat is running at full speed, that is, about eight miles per hour. The screw is 12 inches in diameter, and normally makes 700 revolutions per minute; its shaft is connected with the armature shaft through rawhide gears. The motor is series wound, the field winding being in four sections, so arranged that by means of a switchboard various combinations of the field coils can be obtained. A reversing switch is provided, so that the boat may be driven in either direction, and by means of another switch three combinations of the storage cells may be obtained, giving respectively 10, 20 and 40 volts. With a single charging the boat, it is said, will run easily 50 miles without injury to the batteries.

Distribution of Power by Alternating Currents: Preliminary Statement.

BY WILLIAM STANLEY, JR., AND JOHN F. KELLY.

As the series of articles now appearing in *La Lumière Electrique*, by M. Leblanc, on the distribution of power by means of alternating currents directly bear upon certain investigations made by the authors on the same subject, we desire to make a preliminary statement of our work.

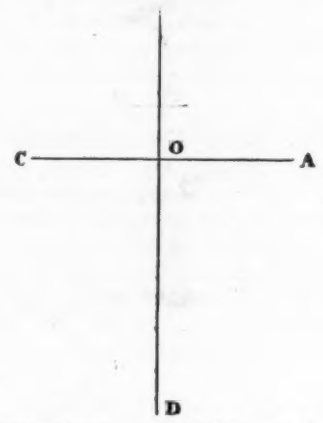


FIG. 1.—DISTRIBUTION OF POWER BY ALTERNATING CURRENTS.

$O\,A$ = impressed E. M. F.; $O\,B$ = condenser E. M. F.; $O\,D$ = self-induction E. M. F.; $O\,C = R\,I$.

As is well known, the principal difficulties encountered in operating motors by alternate current are caused by self-induction in the field and armature circuits. But for the presence of this factor, an ordinary shunt or series wound motor properly designed to avoid Foucault currents would operate equally well upon alternate currents of any frequency. When such a motor is supplied with an impressed alternating E. M. F., the self-induction of the field and armature coils causes the currents which flow through them to lag behind the impressed E. M. F. in a manner well understood by electricians. In the case of a shunt motor, it is obvious that the self-induction of the field circuit would oppose the flow of current through it to such an extent as to practically destroy all of the magnetism requisite to operate the motor, and as the self-induction of the field in a shunt motor is very much greater than the self-induction of the armature, the lag of such field current as does leak through against the E. M. F. of self-induction would obviously be much greater than that of the current in the armature. In short, the field and armature magnetizations would be out of phase, and the values of the currents flowing would not represent the torque developed. For the purpose of avoiding these difficulties, the authors have employed a method of annulling the self-induction of a circuit, which, although mathematically expressed by certain writers previous to their work, was but vaguely understood. Briefly stated, this method consists in producing in the circuit possessing self-induction a capacity effect which, when properly chosen for the frequency and self-induction of the circuit, will entirely neutralize the counter E. M. F. of self-induction. Consider a circuit possessing a self-induction of L henrys supplied by an impressed E. M. F. of frequency n, it can be shown that if a capacity of M microfarads be inserted in series in the circuit of such value that $M = \frac{10^6}{4\,\pi^2\,n^2\,L}$ there will be developed an E. M. F. within the condenser which will be equal in value to the E. M. F. of self-induction, and as it is 180 degrees distant from the E. M. F. of self-induction, it will entirely neutralize this E. M. F. during every instant of time. In short, there will be three E. M. Fs. upon the circuit—1st, the impressed E. M. F.; 2d, the E. M. F. of self-induction in quadrature and lagging behind the first; and 3d, the E. M. F. of the condenser in quadrature, and in advance of the impressed E. M. F.

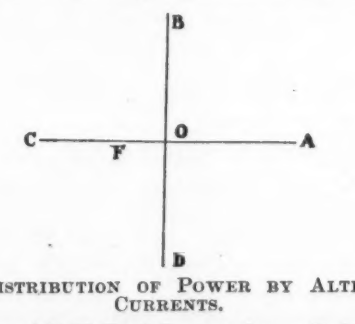


FIG. 2.—DISTRIBUTION OF POWER BY ALTERNATING CURRENTS.

$O\,A$ = impressed E. M. F.; $O\,B$ = condenser E. M. F.; $O\,D$ = self-induction E. M. F.; $O\,F$ = counter E. M. F. of rotation; $F\,C = R\,I$.

The accompanying sketch and diagram illustrate the relative positions of these E. M. Fs. It is not to be understood, of course, that the E. M. F. of self-induction and the E. M. F. upon the condenser disappear or are destroyed by the balancing conditions mentioned above, but that as their values are equal and opposite, their effect upon the current flowing through the circuit is neutralized. As is well known, the counter E. M. F. of self-induction is a function of the current flowing, being $E_s = L\,2\,\pi\,n\,c$, also the back E. M. F. upon the condenser is a function of the current, viz., $E_c = \frac{c\,10^6}{M\,2\,\pi\,n}$. If the values of L and M be chosen such that $L = \frac{10^6}{4\,\pi^2\,n^2\,M}$, then the E_s of self-induction will be equal (and opposite) to the E_c *for all values of current flowing through the two in series*, that is, E_s and E_c will neutralize for all values of current so long as L and M are constant. With these conditions present in a circuit the value of the current derived from an impressed E. M. F. will be equal to the E. M. F. divided by the resistance. But for the purpose in hand a more important result is attained, viz., the lag of the current behind its E. M. F. is avoided, for there is now no active E. M. F. in the circuit except the impressed, and it is evident that the current must coincide in phase with this E. M. F.

We have stated that when a condenser is inserted in the circuit of such size as to develop an E. M. F. of equal value to the E. M. F. of self-induction the current flowing will obey Ohm's law. This is, however, only true in the case of a self-induction which does not include an iron core, and it is likewise only true when the condenser is a theoretically perfect receiver, in which none of the energy stored is wasted. In our experiment, to develop a motor which shall operate upon standard alternating circuits we have employed the ordinary type of two-pole motor, with armatures of both open and closed circuit construction, and we have succeeded in entirely neutralizing the self-induction of the circuits in a perfectly satisfactory manner. In short, we have been able to apply alternating currents to the ordinary type of motor possessing great self-induction, and to develop the field magnetization in the same manner as though the motor were supplied with direct currents of constant value. In developing this subject we have met with many phenomena which are almost outside of the range of ordinary alternating current work, and which we hope to place before the electrical public in a short time. It seems to us that the solution of the problem of the distribution of power by alternating currents is very near at hand.

It is but fair to state that our work in our condenser motor was theoretically completed before the discussion of the Ferranti effect and the publication of the articles on self-induction and capacity that appeared in the foreign electrical journals.

As pointed out above, the self-induction of a circuit can be completely neutralized for a given frequency by a certain capacity interposed in the circuit, so that for this particular frequency the circuit offers no opposition save that due to ohmic resistance. It is obvious, however, that for all other frequencies an opposition other than that of ohmic resistance will appear, for higher frequencies due to an unbalanced self-induction, for lower to an unbalanced capacity. It is clear, however, that as the capacity introduced continues to neutralize the self-induction to some extent for all frequencies, all rates above the normal will get through more readily than if no capacity were present, although the farther they are from the normal the less will they be helped. It is otherwise with lower frequencies. Here the opposition is due to the capacity the new element introduced into the circuit, and for rates a certain amount below the normal the opposition offered by the unbalanced condenser is greater than that previously afforded by self-induction alone. The turning point is that at which $n = \frac{n_1}{\sqrt{2}}$ when n^1 is the frequency for which the circuit is balanced, and n any other rate. When $n = \frac{n_1}{\sqrt{2}}$ the current will get through equally well whether the capacity is present or not; when $n < \frac{n_1}{\sqrt{2}}$ it gets through with more difficulty in the presence of the capacity.

We have applied this principle to a method of sifting out different rates of alternation with remarkable success. By its means we are enabled to practically suppress the troublesome currents in telephone lines due to induction and leakage from electric light, electric power and telegraph circuits. It is in fact necessary merely to break the telephone circuit by a condenser of such a capacity as to let the telephonic currents readily through, while opposing a great opposition to the foreign currents of much lower frequency.

Another application of the method is to multiple telegraphy. We can send over a line a current compounded of a number of different wave lengths and sort these out at the other end, either by leading them into branch circuits separately balanced, or by allowing the compound current to act inductively on a number of local circuits so balanced.

(*Copyrighted*, 1890.)

Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

A. D. 1644.——Descartes (Réné), a prominent French philosopher and mathematician, publishes his "Principia Philosophiæ," an extensive work divided into four parts; the first containing an exposition of the principles of all human knowledge, the second treating of the principles of natural things, and the last two parts developing his long-accepted theory of vortices. His idea was that a rush of subtle porous matter passes rapidly through the earth from the equator towards each pole, and is opposed by magnetic substances during its passage; that the sun is the centre of a vortex of an ethereal fluid, whose whirling motion produces the revolution of planets about the sun, or around the fixed stars, as well as other phenomena. Moreover, as Noad states it, "the vortex moves with the greatest facility in one particular direction, one of its ends being always turned toward the north." This theory, which found many believers, even after Newton's discoveries, has long since been consigned to oblivion.

See his biography in "Biog. Universelle," vol. X., pp. 465–473, Whewell, "Hist. of the Ind. Sc.," vol. I., pp. 323, 328, 338, 339, 343, 354, 387, etc., 423, 429, 430; vol II., p. 220; also vol. I., pp. 320 and 390 relative to Le Père Marin Mersenne, and pp. 391 and 423 concerning the "Traité de Pnysique" of James Rohault.

A. D. 1646.——Browne (Sir Thomas), an eminent English physician and writer, publishes the well-known treatise, "Pseudodoxia Epidemica, or Inquiries into Vulgar and Common Errors," which ran through six editions in twenty-seven years, and upon which his fame is principally established. With regard to the possibility of such a magnetic telegraph as Strada speaks of, he says (book II., chap. III.): "The conceit is excellent, and, if the effect would follow, somewhat divine; whereby we might communicate like spirits, and confer on earth with Meniprus in the moon. And this is pretended from the sympathy of two needles, touched with the same loadstone, and placed in the centre of two abecedary circles or rings. . . . "

He submitted the matter to experiment, and found that "though the needles were separated but half a span, when one was moved the other would stand like the pillars of Hercules, and if the earth stand still, have surely no motion at all." "By electrical bodies," he says, "I understand not such as are metallical, mentioned by Pliny and the ancients; for their *electrum* was a mixture made of gold, with the addition of a fifth part of silver; a substance now as unknown as true *aurichalcum*, or *Corinthian* brass, and set down among things lost by Pancirollus. Nor by electric bodies do I conceive such only as take up shavings, straws and light bodies, in which number the ancients only placed *jet* and *amber*, but such as conveniently placed unto their objects, attract all bodies palpable whatsoever. I say conveniently placed, that is, in regard of the object, that it be not too ponderous or any way affixed; in regard of the agent, that it be not foul or sullied, but wiped, rubbed and excitated; in regard of both, that they be conveniently distant, and no impediment interposed. I say, all bodies palpable, thereby excluding fire, which indeed it will not attract, nor yet draw through it, for fire consumes its effluxions by which it should attract."

At chapter XVII. of the Seventh Book of the treatise above alluded to, Browne makes allusion to "the story of Frier Bacon that made a Brazen Head to speak these words: *Time is* . . ."

See Browne's "Letter" inserted in the "Biographica Britannica," also his entire works, which have been received as an encyclopedia of contemporary knowledge and were published in four octavo volumes by Simon Wilkins, F. S A., London, 1836.

A. D. 1653.——In the third edition of "The Jewell House of Arte and Nature," by Sir Hugh Plat, originally published in 1594 and wrongly attributed in Weston's Catalogue to Gabriel Plattes, is to be found the following allusion to the loadstone: "And though the adamant be the hardest of all stones, yet is it softened with Goa's blood, and there is a special antipathy between that and the loadstone, which is of the color of rusty iron, and hath an admirable vertue not onely to draw iron to it self, but also to make any iron upon which it is rubbed to draw iron also, it is written notwithstanding that being rubbed with the juyce of Garlick, it loseth that vertue and cannot then draw iron, as likewise if a Diamond be layed close unto it."

See J. B. J. Delambre at A. D. 1635.

A. D. 1660.——Guericke (Otto Von), a burgomaster of Magdeburg, Prussian-Saxony, constructs the first frictional electric machine (see illustration), consisting of a globe of sulphur, cast in a glass sphere, and mounted upon a revolving axis, and which, when rubbed by a cloth pressed against it by the hand, emits sound and light. It was Von Guericke who "heard the first sound and saw the first light in artificially excited electricity." He showed that light bodies, when once attracted by an excited electric, were instantly repelled by the latter and were incapable of a second attraction until touched by some other body; also, that light bodies become possessed of electrical excitation when suspended within the sphere of an excited electric.

See "Experimenta Nova Magdeburgica," 1672, lib. IV., cap. 15, page 1,471, also a copy of all relating to the sulphur globe reproduced from the "Experimenta Nova" at end of Figuier's "Exposition et Histoire, etc.," vol. iv, Paris, 1857. Schott (Gaspar), "Technica Curiosa, etc.," Norimburgæ, 1664.

A. D. 1661.——Somerset (Edward), second Marquis of Worcester, an English inventor, announces in his "Century of Inventions," that he has discovered "a method by which, at a window, as far as the eye can discover black from white, a man may hold discourse with his correspondent, without noise made or notice taken; being, according to occasion given, or means afforded, *ex re nata*, and no need

OTTO VON GUERICKE.

of provision beforehand: though much better if foreseen, and course taken by mutual consent of parties." This method, he asserts, he can put into practice "by night as well as by day, though as dark as pitch is black."

See Dirck's "Life of Worcester," p. 357.

A. D. 1662.——Rupert, Prince Robert, of Bavaria, son of Frederick V., elector palatine, and one of the founders of the Royal Society of London, is credited with the discovery of the curious glass bubbles called "Rupert's drops." These are merely drops of glass thrown, when melted, into water and then suddenly consolidated into a shape somewhat resembling the form of a tear. The thick or globular end may be subjected to quite a smart stroke even upon an anvil without breaking, but if the smallest particle of the tail be nipped off, the whole flies into fine powder with almost explosive violence.

"Mr. Peter did show us the experiment (which I had heard talke of) of the chymicall glasses, which break all

GUERICKE'S FIRST FRICTIONAL ELECTRICAL MACHINE, AS SHOWN IN HIS "EXPERIMENTA NOVA MAGDEBURGICA."

to dust by breaking off a little small end; which is a great mystery to me." (Samuel Pepys, "Diary," Jan. 13, 1662.)

Sir David Brewster discovered that the fracture of these unannealed drops was accompanied with the evolution of electrical light, which pervaded the whole drop so that its form was distinctly visible in the dark, and that the light appears even when they are broken under water. Mr. Bennet observed that when one of the same drops was placed upon a book, the latter was electrified negatively.

See articles "Annealing," "Optics," and "Electricity," in "Encyl. Brit."; also biography in "Penny Cycl.," vol. XX., pp. 226–227.

A. D. 1665.——Grimaldi (Francesco Maria), Italian philosopher, member of the order of Jesuits and an associate of the astronomer Giovanni Battista Riccioli (1598–1671), is the author of the celebrated work "Physicomathesis de Lumine, etc.," which, though treating mainly of the nature of light, contains an account of his experiments in other directions, and cites the discovery of magnetism produced by the perpendicular holding of an iron bar.

See *Phil. Trans.* for 1665, and Ronald's Catalogue for Bononiæ, 1665; also, "Engl. Encyl." art. "Biography," vol. III, p. 207.

A. D. 1665.——Glanvill (Joseph), an eminent English divine and philosopher, Chaplain to the King and F. R. S., sometimes called "Sadducismus Triumphatis Glanvill," endorses in his "Scepsis Scientifica" the views advanced some years previously by the Jesuit Leurechon, and, after discussing the objections of Sir Thomas Browne, expresses the belief that "to confer at the distance of the Indies by sympathetic conveyances may be as usual to future times as to us in literary correspondence."

A writer in the Bath *Chronicle*, not long since, reproduced a long extract from Glanvill's work, the concluding sentence of which, he says, seems to have anticipated the electric telegraph. It is as follows:

" . . . But yet to advance another instance. That men should confer at very distant removes by an extemporary intercourse is a reputed impossibility; but yet there are some hints in natural operations that give us probability that 'tis feasible, and may be compassed without unwarrantable assistance from demoniack correspondence. That a couple of needles equally touched by the same magnet, being set in two dials exactly proportioned to each other, and circumscribed by the letters of the alphabet, may effect this 'magnale' (*i. e.*, important result) hath considerable authorities to avouch it.

"The manner of it is thus represented: Let the friends that would communicate take each a dial, and, having appointed a time for their sympathetic conference, let one move his impregnate needle to any letter in the alphabet, and its affected fellow will precisely respect the same. So that, would I know what my friend would acquaint me with, 'tis but observing the letters that are pointed at by my needle, and in their order transcribing them from their sympathised index, as its motion directs; and I may be assured that my friend described the same with his, and that the words on my paper are of his inditing. Now, though there will be some ill-contrivance in a circumstance of this invention, in that the thus impregnate needles will not move to, but avert from each other (as ingenious Dr. Browne hath observed), yet this cannot prejudice the main design of this way of secret conveyance; since it is but reading counter to the magnetic informer, and noting the letter which is most distant in the Abecederian circle from that which the needle turns to, and the case is not altered.

"Now, though this desirable effect may possibly not yet answer the expectations of inquisitive experiment, yet 'tis no despicable item, that by some other such way of magnetick efficiency it may hereafter with success be attempted, when magical history shall be enlarged by riper inspections; and 'tis not unlikely but that present discoveries might be improved to the performance."

See *Nature*, vol. XVI, p. 269.

A. D. 1666.——Denys (William), hydrographer, of Dieppe, observes that the compasses placed in different parts of a vessel give different indications. (Becquerel, "Magnétisme," p. 119.)

A. D. 1671.——Richer (T.), French philosopher, who was sent by the Paris Academy of Sciences to the island of Cayenne for the purpose of determining the amount of terrestrial refraction and for other astronomical objects, is the first to make known the electrical powers of the *gymnotus electricus*.

See Leithead, "Electricity," chap. XII.; Fahie, "El. Tel.," p. 171; Bertholon, "Elec. du Corps Humain," 1786, vol. I., p. 171; *Mem de l'Acad. des Sciences*, 1677, art. VI.; Richer, "Observations, etc.," Paris, 1679.

A. D. 1671.——Rohault (Jacques), a French philosophical writer, and one of the earliest, ablest and most active propagators of the Cartesian philosophy in France, publishes at Paris the first edition of his "Traité de Physique," at part III., chap. VIII., pages 198–236 of which he treats especially of amber and of the loadstone. The same passages can be seen at vol. II, part III., chap. VIII., pages 163, etc., of Rohault's "System of Natural Philosophy," published in London during the year 1723, and at the same chapter, pages 388, etc., of "Jacobi Rohaulti Physica," Londini, 1718.

The latter is the last and best edition of the well-known classical translation, originally made in 1697, by Dr. Samuel Clarke, an eminent English theologian and philosopher, who was the friend of Sir Isaac Newton, and at that time occupied the post of chaplain to Moore, Bishop of Norwich. Through this new work Clarke was enabled to introduce numerous critical notes exposing the many fallacies of the Cartesian system, and his treatment of the subject was so favorably received that the "Physica" passed through four editions as the Cambridge University text-book before it was made to give way to the treatises of Newton, as had been the original design of its author.

A. D. 1672.——Sturm (John Christopher), a very able German mathematician, who was for 34 years professor of natural philosophy at the University of Altdorf (Franconia), and who, after vainly attempting to satisfactorily unite the Aristotelian and Cartesian doctrines, finally adopted the Baconian philosophy, establishes the "Collegium Curiosum" on the plan of the celebrated Italian "Accademia del Cimento."

The society was founded for the purpose of studying, repeating and even modifying the most notable philosophical experiments of the day, such as those made by Von Guericke, Boyle, Hooke and others, and its proceedings were published in 1676 and 1685 under the title of "Collegium Experimentale sive Curiosum, etc."

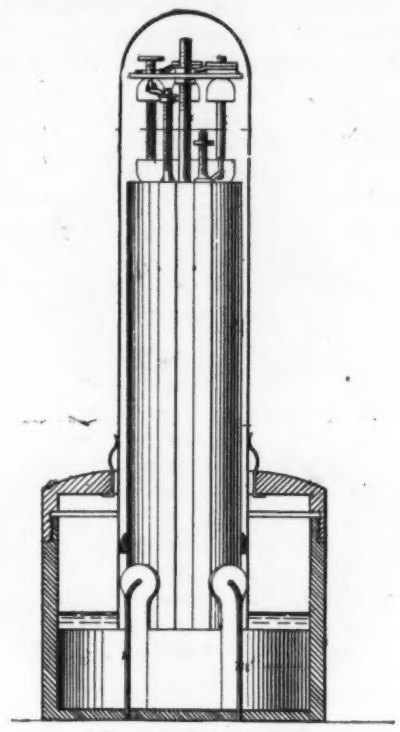
* Continued from THE ELECTRICAL WORLD, June 6, 1891.

The Incandescent Lamp Suit.

Last week we gave a brief *résumé* of the history of the claims on which the infringement suit, recently closed, was based, and of the previous litigation that had led up to the present battle of the giants in incandescent lighting. The general policy pursued by the complainant in this suit has been to bring before the eyes of the Court as clearly as possible, the commercial success that has been attained by the Edison lamp, the struggles of the inventor in persuading even the scientific public of the possibilities of his plans, his successful avoidance of the difficulties that had embarrassed many of his predecessors, and the unquestioned great effect of his work on the succeeding state of the art. Mr. Edison's name is a potent one to conjure with, and his labors in incandescent electric lighting have undoubtedly been long and great.

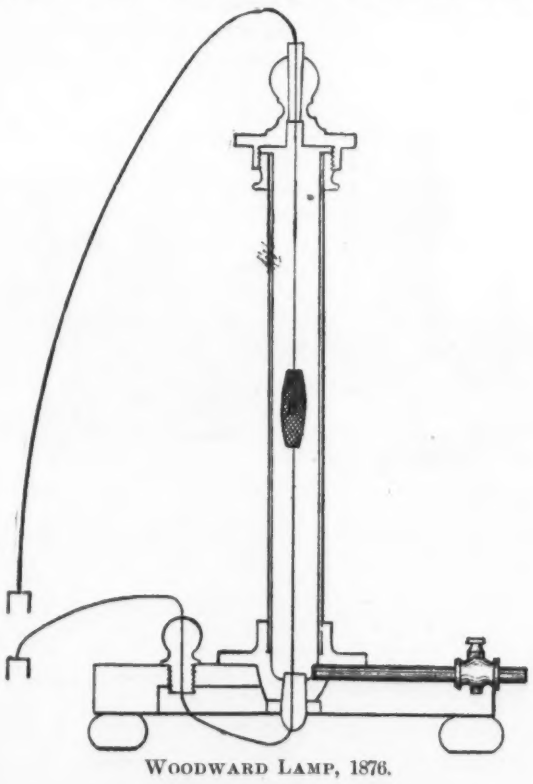
It was shown by the complainant, as evidenced in Mr. Dyer's argument, that up to the time of the Edison lamp all or nearly all the previous attempts had been with low-resistance carbons totally incapable of doing the work that is done by the Edison filament. It was further shown that up to the time of Edison's work the very suggestion of incandescent lighting would bring a smile of incredulity to the face of any scientific man before whom the subject was mentioned. The bungling experiments of Fontaine, to drop into the vernacular, had given the incandescent lamp a black eye, and a period of comparative lethargy lasting something like five years succeeded the efforts made about 20 years ago to revive in practical form the lamp that King had brought to the attention of the scientific world in 1845. It is not generally known how clear an understanding King had of the situation. In default of a proper mercury pump King used the Torricellian vacuum for his lamp, and shows in his patent a platinum wire sealed into the top of the lamp-bulb and connected with the carbon, the other terminal being carried down and connected by means of a copper wire with the mercury in the tube below the bulb. According to King's specification the carbon was to be worked into the form of very small pencils or thin plates, and enough is known of his experiments to show that the lamp burned, and burned well, although probably not for any very long time. On one occasion he had no less than 26 of these lamps, one for each State of the Union at that time, connected up in a chandelier and on exhibition; and his specification more than suggests the complete sealing up of the lamp, although the method of doing it is not specified, so that one cannot definitely say that he proposed doing it by sealing both wires into the glass instead of one. He understood perfectly well that carbon was a thoroughly available material for the burner, that it must be protected by a vacuum, that the vacuum should be of the most perfect kind obtainable; the Torricellian vacuum he adopted was the best then known in the arts. Further, King specified that the carbon rod should be very small, although the limits of dimensions were not given. After this, about 1865, came the attempts of Adams at an incandescent lamp, referred to in our previous article. Adams undoubtedly tried the carbon burner in an exhausted globe with platinum leading wires sealed through it, but, unfortunately, his experiments were not made sufficiently public to prove of any great value in the present litigation; and then came the period of activity abroad, during which the lamps of Konn, Kosloff and others appeared. Their lamps were like King's, composed of very thin carbon rods heated to incandescence in a closed chamber, though the latter was not exhausted but, by a retrogressive step, filled with nitrogen. It was at that time that Fontaine's experiments rather quashed the interest that was felt in incandescent lighting. Nevertheless the experiments continued, Lane-Fox and Swan in England, Woodward, Sawyer and Man, Farmer, and Edison in the United States, were engaged vigorously in seeking a way out of the difficulties of their predecessors.

The defence in the present case is for the most part an attack on the validity of the Edison patent, based on the previous state of the art, and alleging lack of patentable invention. We show two cuts by way of illustrating some of the earlier incandescent lamps. One of them is the rod lamp of Kosloff in 1875, containing a series of thin rods attached to it, thrown into action successively as one after another might burn out; the light from each carbon was from a few minutes to a few hours at the most. The bulb was filled with nitrogen, and was closed, not by sealing, but by tight joints. The second lamp shown is that of Woodward, patented in 1876, and is one of the nearest early approaches to the present practice. The lamp was a glass tube hermetically sealed at the two ends, in the drawings shown closed by caps, although it should be said that sealing through glass with platinum had been for many years a recognized and well-known method of hermetically sealing. The tube was to be exhausted of air and then the small sheet of carbon brought to incandescence by the electric current. Woodward proposed, too, to use a rarified gas that did not support combustion, and to place the lamps in parallel across mains. It is a significant fact that this Woodward patent is owned by the Edison company, and that a very similar suggestion as to the use of an inert gas at low pressure is made in Edison's own patent of March 20, 1883, in which he observes that a very high vacuum is deleterious in causing the carrying away of the carbon by the current, and proposes the use of a considerably lower vacuum of an inert gas. The claim in Edison's patent on which the greatest reliance is placed is that for the combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, from which receiver the air is exhausted. Now, in taking up this claim in detail the defense lays stress on the implicit or explicit anticipation of the features in this claim that embody invention, attacking its novelty on the following grounds: The utility of carbon as a substance



Kosloff Lamp, 1875.

for the burner of an incandescent lamp has been known for nearly 40 years, and had been recognized by every experimenter in the field; the effectiveness of a high vacuum to protect the carbon burner from destruction was also well known. Both King and Roberts in their respective patents teach that the vacuum shall be made as perfect as possible, and each of them used the best means then obtainable for securing this condition. The use of a receiver entirely of glass with platinum leading wires sealed through it, as a means of preserving a high vacuum, was by no means new at the time of Edison's application. King more than suggested it, Geissler tubes had been in use for nearly 30 years, Crookes' radiometers, in which the vacuum was even more perfect than in Geissler tubes, were well known to the scientific world. Adams had in



Woodward Lamp, 1876.

all probability constructed lamps with carbon burners, embodying this particular feature; and, finally, in the provisional patent granted to Lane-Fox in England, Nov. 14, 1878, the patentee states that his method of construction of incandescent lamps is to coil a wire (of platinum or platinum and iridium) into the form of a spiral, and to attach the two ends to platinum wires fused side by side into a piece of glass, and then to seal this glass plug with its leading wires and spiral into the mouth of a flask provided with a neck by which it is to be exhausted, and the tube then sealed off. This will be recognized as a tolerably clear description of the present manufacture of incandescent lamps, except that the burner was, in the Lane-Fox lamp, of platinum alloy instead of carbon. As regards the important claim of using a conductor of high resistance, it must be conceded that most experimenters had made lamps of less than five ohms resistance, but in the Lane-Fox patent of Oct. 9, 1878, the inventor specifies that the material for the burner should have a high specific resistance, that its resistance and extent of surface should depend on the amount of light desired, and that he prefers to use considerable lengths of fine wire so as to get a high resistance without a large extent of luminous surface and to use, for the purpose of a better and more economical distribution at comparatively high tension, 100 volts being the figure named in this patent. Edison, in a French patent of May 28, 1879, prior to the application for the one in suit, describes an incandescent burner in which platinum wire of as high as 750 ohms resistance is employed, and it may be further mentioned that Lane-Fox's provisional patent of March 20, 1879, calls for an incandescent conductor having a resistance of 300 ohms used at an electromotive force of 140 volts. He proposes, too, to make his burners out of plumbago mixed with some badly conducting material so as to secure the necessary high resistance.

These anticipations raise some doubt as to the patentability of the Edison invention in question, a point that must be decided by the court in one way or another; for there may be a very reasonable doubt as to the invention involved in giving the carbon burner a small cross-section and a small radiating surface, as instanced both by Lane-Fox and Edison's own platinum lamp. In the first place, it is doubtful if there was any patentable invention in making a filamentary burner out of a particular kind of carbon, as carbon was thoroughly well known in the art. Still further, the all-glass globe, and even the method of construction, were so nearly approached by Lane-Fox that additional doubt is raised on these scores. In contravention of this is placed the undoubted general influence of Edison's work. This was put in rather plain terms by Judge Bradley in his famous decision in the Sawyer-Man fibrous filament case during the McKeesport suit. Judge Bradley says: "The claims of the patent may be summarized as follows: First, a conductor of carbon made of fibrous or textile material and of arched form; 2nd, a conductor of carbon made of fibrous material in a hermetically sealed chamber without regard to form; 3d, the combination of a conductor of carbon made of fibrous or textile material in an arched form in a glass chamber hermetically sealed and deprived of carbon consuming gas. The claim of the combination last named may be dismissed from consideration as a separate claim, because a glass chamber hermetically sealed for holding the light has always been used, and must necessarily be used in all incandescing carbon electric lamps; it was used by King in 1845, by Konn in 1872, by Kosloff in 1875 and by others. Unless the patent is valid for the conductor of carbon made of carbon or textile material in an arched form, it cannot be held valid by combining such conductor with a glass chamber hermetically sealed. The arched or bent shape in incandescent conductors was applied in 1848 by Staite to an iridium conductor, in 1858 by Gardiner and Blossom to a platinum conductor, and in 1872 it was a well-known fact in science and the arts. Long prior to 1878 it was a well-known fact in science and the arts that the transmission of the electric current through a pencil of charcoal interposed in a metallic circuit would produce intense light, and that when this charcoal was guarded from contact with oxygen, in a vacuum or otherwise, it would not be consumed. The great desideratum was to construct an apparatus and to discover a process which would make the light economical and convenient, of use for ordinary and domestic purposes. We are clearly of opinion, therefore, that neither Sawyer and Man nor Edison can maintain any such claim to the exclusive use of charcoal generally in any form as the incandescing conductor in an electric lamp." The Judge goes on to point out, after this summary of the state of the art, that it was very clear to him that there was a change of base on the part of Sawyer and Man, the complainants in the case, after the issue of the Edison patent, and the upshot of the suit was to overthrow the claims of Sawyer and Man in consideration of both early anticipations and their own modifications introduced after Edison's work on the subject. In summing up, Judge Bradley says that the principal and great thing described in Edison's patent is the attenuated filament and its inclosure in a perfect vacuum, and that this particular invention made practicable the present incandescent lamp.

At first sight it might seem that no very exact definition of the word "filament" would be needed. By that term we usually understand a thread-like affair of small diameter, such as we find in the lamp of to-day; but since carbon rods of small diameter and perhaps four or five ohms resistance had already been used in incandescent lamps, the question naturally arises, at what point does a bit of carbon become a filament and cease to be a rod? This is more than a casual question, for on it hinges much of the merit that might be ascribed to the use of high resistance. The arched form of conductor is undoubtedly old, and therefore the inquiry takes the form as to the filamentary or else rod-like character of a straight piece of carbon in an incandescent lamp. The only particular resistance mentioned by Edison in his patent was 100 ohms. It is hardly to be presumed that he confined himself to that particular figure. If such were the case the ordinary lamp for use on alternating circuits would not fall within the patent,

and besides, there might be much doubt as to the amount of invention in substituting a carbon conductor of 100 ohms for the platinum conductor of even greater resistance used both by Lane-Fox and by Edison himself, considering that both materials had been previously used interchangeably in lamps of low resistance. If, on the other hand, the term "filament of high resistance" covers conductors like those used, for example, in battery lamps and in series with arc lamps on arc circuits, the question naturally arises whether the increase in resistance in those over that of the straight rods found in the lamps of King and Kosloff, the early Sawyer-Man lamps and others, is sufficient to constitute a patentable invention. A lamp constructed by Edison experts, of the materials mentioned in the Edison patents, and of the dimensions shown in the patent drawing, gave a resistance of only 12½ ohms hot, although one intended as a duplicate of the Patent Office model showed a resistance of about 40 ohms.

Now, if carbon lamps of 4 ohms resistance were old, and platinum lamps of from 100 to 700 ohms were old, would there be any patentable invention in constructing a carbon lamp of 12½ ohms resistance? If not, at what resistance would the patentable novelty of the increase in resistance begin?

Putting aside, now, all the more technical points raised by the defense, and basing the consideration of the matter solely on the state of the art at the time Edison applied for the patent in question, it needs no argument to show that the case is one requiring, to say the least, close discrimination. There are various side lights that may be thrown on the issue; among them the late date at which the suit was brought; the immense capital invested in a manner that depends on the use of the incandescent lamp; the long interference between the principal litigants in the Patent Office in the attempt to obtain broader claims for each; the change in general practice that followed the introduction of the Edison lamp to public notice—all these, whatever their legal force, must be weighed by one who desires to form an unbiased opinion. Nor are they without legal importance, for there is a certain moral force in them that can hardly escape producing its effect. The Patent Office has come in for its share of interesting work in the invention involved. Not that its rulings are always infallible—quite the contrary, as witness the transformer patent denied to one inventor as impossible, and yet a few years later issued to another. In 1881 Mr. W. K. Freeman filed an application for an incandescent lamp, and in an amendment inserted the following claim: "An electric lamp for giving light by incandescence, consisting of a strip or filament of carbon of high resistance inclosed within an exhausted receiver made entirely of glass and attached to metal wires passing through and sealed into the glass as set forth." This naturally came into interference with the Edison patent, but the Patent Office suspended its interference to cite Crookes' radiometer as a reason for rejecting the Freeman application. The particular radiometer referred to is one in which a ring or spiral of platinum is placed in the interior of an exhausted globe, the terminals being sealed through it. This doubtless was not intended by Crookes directly for an electric light, but the Patent Office in rejecting Freeman's application said: "It is not deemed material that applicant claims a carbon filament in place of the platinum conductor shown in the reference, the substitution of one for the other being within the skill of one well versed in matters pertaining to electric lighting, it being old in the art to use carbon conductors for incandescent lamps as shown in King's English patent." The reference given is said by the Patent Office to be newly discovered. What would have been the effect had it been equally well known to the office at the time of the Edison application?

To sum up the matter as fairly as possible, Edison's claims, as stated in his patent now in litigation, do not seem to be at all commensurate with his real effect on the art of electric lighting. His labors in that field have done much to bring the modern incandescent lamp to its present state of perfection, and he has, certainly, had more than one direct imitator. In bringing suit for infringement, however, it becomes necessary to base the contest on claims that have been allowed by the Patent Office, and the issue of the present case must, necessarily, turn on the breadth of interpretation given to the second claim of his famous patent. Whether, in view of the state of the art at the time of the application, the Court can give to that claim as broad a construction as is necessary to cover the modern lamp, is a matter of considerable doubt.

A Pneumatic Analogue of Wheatstone's Bridge.

The pneumatic bridge is an instrument invented by Mr. W. N. Shaw, of Emmanuel College, Cambridge, for comparing the capacity which different orifices and tubes possess for transmitting air. It was described in a paper read at the recent meeting of the Physical Society at Cambridge. By its means it is possible to study the relative advantages of systems of ventilation and other questions connected with currents of air, for the readings of the instrument are directly and accurately proportional to the quantities of air delivered. Such an instrument has long been desired in the scientific study of ventilation, where the measurements have been generally made with anemometers.

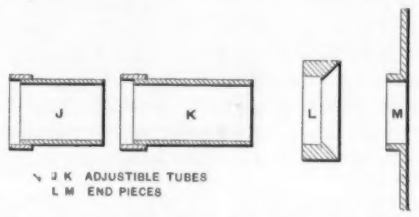


FIG. 4.—ADJUSTABLE CYLINDRICAL TUBE.

Those of our readers, says the London *Industries*, who are acquainted with the Wheatstone bridge method of comparing the resistances offered by wires to the electrical current, will readily follow the theory and working of this new bridge, for it bears a strict analogy to that instrument. It, as at present constructed, consists of three airtight boxes, one of the size of 4 feet by 1½ feet by 1½ feet, and two of the size of 3 feet by 1½ feet by 1½ feet, arranged and fastened together in the manner shown in Fig. 1. In the middle of the upper side of the transverse box is a metal chimney containing a gas flame, by means of which the necessary draught is obtained. This flame can be altered in size so that the head of air may be made greater or less. It has been found that in this particular instrument the head can be varied in the ratio of four to one. To obtain a greater draught a revolving fan can be used. Between the transverse and the two lateral boxes are two equal openings *C* and *D* of about 1½ inches diameter, and it is through them that the air is drawn from the side boxes. They are circular openings cut in the thinnest possible sheets of mica, and represent in the electrical analogue two equal resistances. At a point one foot distant from the far ends of the side boxes is a glass tube about 1.1 inches in diameter, connecting them, and in it at its centre is a small magnetic vane *G* (Fig. 1). As the sensitiveness of the apparatus depends on the indicator employed, we shall quote Mr. Shaw's description of it: "The one tried and found to work well consists of two very small parallel sewing needles, stuck through a cap of elder pith, supported on a small agate compass centre. The needles carry very light mica vanes on one side of the centre, counterpoised by a small quantity of platinum wire. The whole is balanced on the point of a fine needle, and forms a very delicate wind vane." The needles are magnetized and maintained in a fixed direction by an external control magnet, so that their points are opposite a fiducial mark in the glass tube. The sensitiveness can be altered as desired by the external control magnet just as that of a galvanometer needle can be.

One foot nearer are two other orifices *A* and *B* (Fig. 1), one of which is a graduated and adjustable slit shown in Fig. 2 and the other is the particular orifice or tube of which the air transmitting capacity is required. *F* is an additional aperture for other experiments. The two openings *A* and *B* are analogous to the other two resistances in Wheatstone's bridge, one of which is a known variable and the other the resistance to be determined.

Let us trace now the passage of air through the instrument due to the draught in the chimney. It will enter by the orifices *A* and *B* in proportion to their capacities, and if they are exactly equivalent to one another in exactly equal quantities. It will then pass through the side boxes to the two orifices *C* and *D*, and through them pass into the transverse chamber to the chimney, since *C* and *D* have equal transmitting capacities. But if the quantities entering *A* and *B* are not the same, then part of the air from that side on which more is admitted will find its way by the glass tube to the side where less enters, and in doing so will deflect the vane in the opposite direction to its motion like a weathercock. If the experimenter now alters the adjustable slit *A* until the vane returns to its position of rest, he will have restored equilibrium between the currents. The orifice at *B* can now be changed for another, and the adjustment again made. In this way the comparisons we are about to describe have been made.

At the meeting of the Physical Society at Cambridge Mr. Shaw exhibited a piece of ordinary sheet zinc with a circular hole cut in it, having a slight bevel on one edge. He explained that it was some 10 per cent. better as an air transmitter when placed with the bevel outward. This same result was shown in another way: two equal sized tubes of wood, shown in section in Fig. 3, were compared, one ending with a flush edge and the other ending in a trumpet. The latter was nearly a half again as efficient as the former. This advantage of trumpet-shaped orifices is used on steamships, where the ventilators for the engine rooms are expanded into large trumpets which can be turned toward the wind. The explanation of the increased capacity depends on the prevention of small vortices which occur just inside a tube with a flush end, there being the same formation of a contracted vein with air as there is in an ordinary water jet.

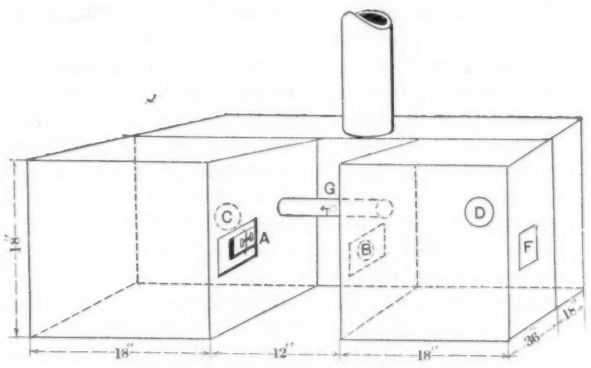


FIG. 1.—SHAW'S PNEUMATIC BRIDGE.

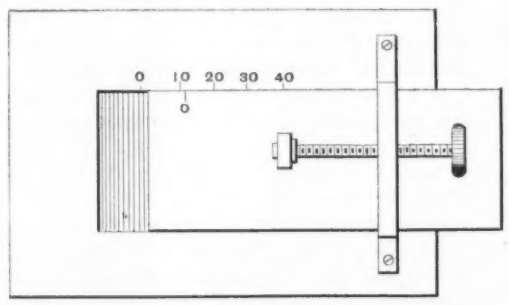


FIG. 2.—SHUTTER WITH TANGENT SCREW AND SCALE.

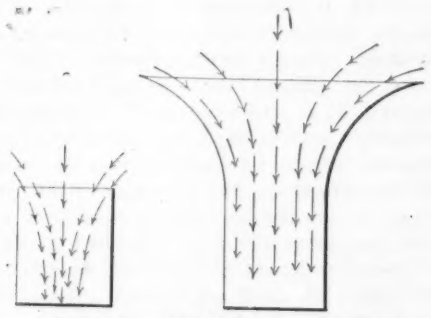


FIG. 3.—PNEUMATIC TUBES.

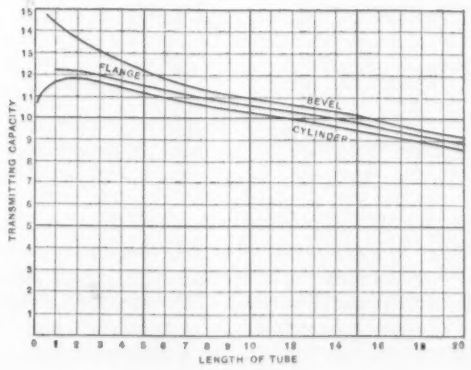


FIG. 5.—EFFICIENCY CURVE.

The comparative efficiency of different lengths of a cylindrical tube ending flush, with a flange and with a bevel, is exhibited in the diagram Fig. 5, where horizontal distances represent increasing lengths of tube and vertical distances represent transmitting capacity. It will be noticed that, with the adjustable cylindrical tube represented in Fig. 4, the first small length placed in front of a circular aperture has the effect of increasing the quantity of air admitted. Further increase of length of the tube reduces by friction the capacity for transmitting air. Another result which has been established by experiments with the bridge is that two circular apertures in a thin plate of mica are precisely equivalent to one circular aperture whose area is equal to the combined area of the two.

Many useful applications for this instrument will suggest themselves. Various ventilators might be compared by attaching small models to the bridge, and the friction in chimneys and cowls might be determined. It would also be serviceable in directly comparing gas meters. If water were the fluid used in place of the air many other applications may be found. Plumbers would find it useful in comparing the effect of bends, stops and cocks, while the hydraulic engineer could test the efficiency of waterways. For this purpose Mr. Shaw has suggested the use of two canal locks connected by a cross channel.

The Frankfort Electrical Exhibition.

The Frankfort Electrical Exhibition has been opened under very favorable circumstances. A brief review of some of the principal features of the exhibition, as given by the correspondent of *The Electrician* (London), may be of interest. The boiler house lies directly behind the great Machinery Hall, and here are 21 boilers of various kinds and sizes, of which 20 are already in use or ready for use. The total heating surface of these is more than 27,500 square feet. Among these may be mentioned two of 2,300 square feet heating surface, each by Steinmüller, of Gummersbach, which provide, through steam engines of a total of 430 h. p., the necessary power for Schuckert & Co.'s dynamos and those of Woodhouse & Rawson, of London.

Siemens & Halske, of Berlin, have undertaken the erection of a central station for the distribution of electric current. They occupy a large space on the extreme right of the Machinery Hall, and their installation will shortly be complete. The direct current installation consists of a three-cylinder compound steam engine by Kahn, of Stutt-

gart, and a direct coupled interior-pole dynamo of 500 h. p. The current will be supplied by means of a direct current transformer at the necessary pressure for the charging of a battery of 168 Tudor accumulators, having a capacity of 540 h. p. hours, arranged in two parallel rows. A portion of the current, by means of a second transformer, will be used for an electric tramway. The alternate current installation includes a two-cylinder compound steam engine by Buckau (Magdeburg), to which is directly coupled a 400 h. p. alternator, and an interior-pole machine coupled directly to a steam engine by Daevel, of Kiel. The alternating current is transformed into a continuous current by a 200 h. p. step-down transformer (2,000 to 150 volts) to charge accumulators, and by a 100 h. p. and a 50 h. p. transformer to supply current for lighting purposes. By means also of four step-up transformers (2,000 to 20,000 volts) a portion of the current will be delivered for lighting the main exhibition, the requisite cable being from Siemens Brothers, of London.

Schuckert & Co., of Nuremburg, whose installation is also not quite ready, exhibit several steam engines from 270 h. p. downward, and many dynamos and motors; they also undertake the lighting of a great part of the exhibition. The Thomson-Houston Company, of Hamburg, shows in the Machinery Hall two dynamos, one of about 40 kilowatts (180 ampères and 220 volts) for transmission of power, and a 17.5-kilowatt machine for arc lamps and glow lamps in series. In the workshop buildings the company has an electromagnet capable of lifting a weight of one ton, intended for the transport of iron castings in ironworks.

The Helios Company, of Cologne, occupies the central part of the hall, and, after the Siemens & Halske exhibits, this company's space will probably prove the most attractive; moreover, the greater part of their exhibits are ready. On the south side of the hall the company has a 600 h. p. steam engine by Paucksch, of Landsberg, coupled to a 2,000-volt 400-kilowatt alternator. This machine, besides supplying lighting current to the exhibition ground, will deliver 30,000 watts for lighting purposes at the Palm Gardens, at the other end of the town. The company has also a 200 h. p. steam engine by Sulzer, of Wintherthur, driving a 2,000-volt 40-ampère alternator, and a direct current machine giving 65,000 watts at 110 volts.

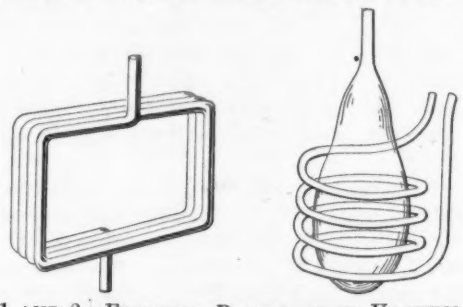
The entire output of the dynamos worked by steam is put down at 3,747 h. p.; those run off gas engines give 203 h. p. Altogether, about 31 firms are showing dynamos, electromotors and transformers, while 20 exhibit steam engines and 12 firms gas engines. The large size of the Machinery Hall prevents overcrowding, and the machines are placed in such a manner as to be of easy inspection by the visitor. The execution of the project for the transmission of 300 h. p. from Lauffen-on-the-Neckar to the exhibition has unfortunately been delayed. It was found that the necessary transformers and insulators could not be procured in as short a time as was anticipated. The two firms which have undertaken the scheme, namely, the Allgemeine Electricitäts Gesellschaft, of Berlin, and the Maschinenfabrik, of Oerlikon, have, however, bound themselves under penalty to have the system in working order by August 15. There seems, then, no doubt that this important experiment, which is awaited with so much eagerness, will be carried out. The manufacture of the conductors is already commenced by the postoffice authorities, and the 10,000 large insulators which will be necessary have been ordered. It will be remembered that the electricity is to be generated by means of an alternator driven by water power on the Neckar, and that the current is to be generated at a pressure of 50 volts, transformed up to 25,000 volts, and transmitted by three wires of four millimetres thickness across the 110 miles of country separating Lauffen from the exhibition.

The Department for the Distribution of Electricity has a separate building devoted to it at the back of the Machinery Hall. Here are shown transformers, both alternating and direct, of all kinds, pressure regulators, automatic rheostats, etc. Running down either side of this are the workshops, the motive power of which is derived from the Machinery Hall. The technical arrangements of these workshops are in the hands of Engineers Sarasin and Stahl. Some 35 motors of different types, and varying from $\frac{1}{15}$ to 25 h. p., are at work. The current is derived from three sources—partly from the main Machinery Hall, partly from the electrical station set up at the Palm Gardens, distant about three-quarters of a mile, and the rest is transmitted from Offenbach, about seven miles up the Main. From the two last-mentioned places the current is transmitted overhead at a high pressure, and transformed down to the necessary low pressure. One of the most interesting of the workshops will be the glow lamp manufactory of Maatschappy, Gelnhausen, and another the manufacture of small lathes and clocks, etc., by Wolf, Tahn & Co., of Frankfort, small Hartmann & Braun motors being used.

Finally, on the left of the Machinery Hall a large pile of earth has been heaped up, on one side of which is a large pond, with an artificial waterfall running into it down the side of the mound, which produces beautiful effects when lighted up from underneath by electricity. On the top of the mound is a convenient restaurant, with a tower illuminated by numerous glow lamps. A model mine is arranged under the mound, with underground electric railway, electric boring machines, etc., and lamps which ought to make gas explosions out of the question.

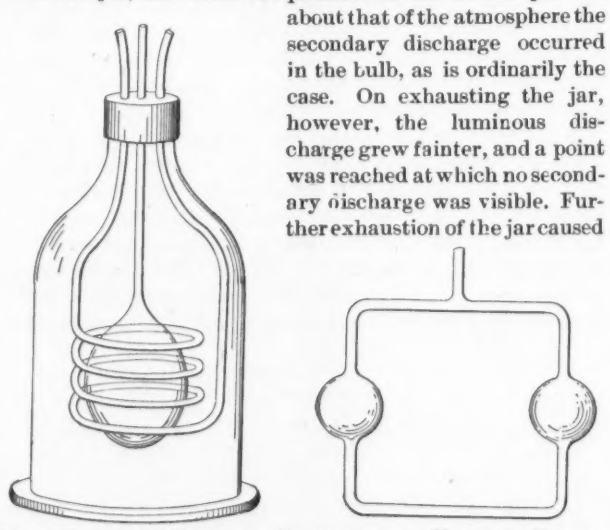
Some Experiments on the Electric Discharge in Vacuum Tubes.

In a recent address before the Physical Society of London, Prof. J. J. Thomson said that the phenomena of vacuum discharges were greatly simplified when their path was wholly gaseous, the complication of the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in tubes devoid of electrodes was, however, not easy to accomplish, for the only available means of producing an electromotive force in the discharge circuit was by electromagnetic induction. Ordinary methods of producing variable induction were valueless and recourse was had to the oscillatory discharge of a Leyden jar, which combines the two essentials of a current whose maximum value is enormous and whose rapidity of alternation is immensely great. The discharge circuits, which may take the shape of bulbs, or of tubes bent in the form of coils, were placed in close proximity to glass tubes



Figs. 1 and 2.—Electric Discharge in Vacuum Tubes.

filled with mercury, which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary nor secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing the self-induction of the primary reduces the electromotive force induced in the secondary, while lengthening the secondary does not increase the electromotive force per unit length. Two or three turns (Fig. 1) in each were found to be quite sufficient, and, on discharging the Leyden jar between two highly polished knobs in the primary circuit, a plain uniform band of light was seen to pass round the secondary. An exhausted bulb (Fig. 2) containing traces of oxygen was placed within a primary spiral of three turns, and, on passing the jar discharge, a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow, which lasted for a second or more. On heating the bulb the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electromagnet. Another exhausted bulb (Fig. 3), surrounded by a primary spiral, was contained in a bell jar, and when the pressure of air in the jar was about that of the atmosphere the secondary discharge occurred in the bulb, as is ordinarily the case. On exhausting the jar, however, the luminous discharge grew fainter, and a point was reached at which no secondary discharge was visible. Further exhaustion of the jar caused



Figs. 3 and 4.—Electric Discharge in Vacuum Tubes.

the secondary discharge to appear outside the bulb. The fact of obtaining no luminous discharge either in the bulb or jar the author could only explain on two suppositions, viz., that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished until a certain point was reached, and afterward diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the presence of the electrodes. One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would prevent a luminous discharge in that tube.

An Alternate Current Potentiometer.*

Prof. Elihu Thomson: As to the degree of accuracy attainable in this way, if I remember correctly, some tests were undertaken some two or three years ago by us to determine what was the smallest increase or decrease of voltage suddenly brought on that would show in a lamp, and I think it was about $\frac{1}{10}$ of a volt.

Mr. Edward Weston: We have used that method in endeavoring to arrive at a somewhat difficult problem in connection with an alternating current instrument of great sensibility and portability. I think the method was used about three years ago. The accuracy is greater, the greater the change of course in the electromotive force of current flowing through it. The method is undoubtedly susceptible of very close results indeed.

Prof. E. L. Nichols: I think it will be found that there is a limit to the brilliancy of the lamp which you can use in practice, on account of the eye. If you have too bright a light the eye is not susceptible to small changes. Probably there is a maximum brightness which should be used in order to give the maximum sensitiveness of the method. The change of the lamp will of course increase as you increase the intensity of the lamp. If you go to a point where the lamp dazzles the eye, the eye by its decreasing sensitiveness will overcome this. Our experiments thus far go only to confirm Mr. Weston's statement that the lamp should be burned at quite a high temperature.

Prof. George Forbes: I would suggest that there is a very simple way of enormously increasing the sensitiveness of this method. As I understand it, the way in which you use it at present is to look at the lamp while the continuous current is serving it and then switch it over to the alternating current, and then judge which is the brightest, moving it rapidly back and forward. It seems to me that that method would be enormously more sensitive if you applied two lamps, and used them in a properly constructed photometer with a switch arrangement, which enables you to connect either of them with the alternating or continuous current. Thus you would adjust the potential of the continuous current until you got very near equality, but you would find that one of the lamps was always a little brighter than the other owing to the sensibility of the lamp. You would then alter the distance of the lamps from the photometric screen slightly, so that on reversing the current you would get an absolute equality, and then you would be able to arrive at a much closer comparison and it would not matter if there was a very slight difference in the illuminating power of the two lamps with different voltages. I feel perfectly sure that this would increase the sensitiveness of the method about tenfold.

Mr. Thos. D. Lockwood: I would like to ask those gentlemen who have made this matter a subject of study, whether the eye doesn't eventually tire in watching the indications of the incandescent lamps. I know the ear tires in performing kindred operations for the telephone. I should imagine the eye would tire a little sooner than the ear.

Prof. E. L. Nichols: I think there is no question about that. Any one who works with a photometer becomes very weary. I do not know, however, whether the eye tires more quickly in watching an incandescent lamp and its changing, provided it be not too brilliant, than in reading closely a scale. I think reading a scale rapidly will tire the eye almost as soon as the other operation.

Mr. Waring: I think that the eye does tire, if you watch an incandescent lamp that is up to its normal candle power. At the Perkins lamp factory we occasionally get a lamp with a bad spot in the carbon which comes through the pump room without being noticed. To pick those out we are using at the present time a photographic lens which throws the image of the carbon on a screen right in front of the person who is using the photometer. The light in the photometer is so mild to the eye that the person's eye doesn't tire. One can watch it all the time and thus readily discover slight differences in the carbon, while the person who is hanging the lamp will have his eyes so fatigued with the bright light that he cannot see these black spots at all, and I should think that in any work where a person tried to look at a lamp of normal candle power the eye would soon become fatigued.

Mr. Edward Weston: I presume that Prof. Thomson, who has had considerable experience with photometry in an incandescent lamp factory, must have noticed what almost every one has who has had this kind of work to do, that with an ordinary photometer the eye doesn't seem to get tired at all. The man seems to get more skillful in the use of it, and does the work better in the latter part of the day than when he began to work. I do not think there is any fatigue of the eye. I think the eye gets even more sensitiveness to slight changes.

Prof. Elihu Thomson: My own personal opinion about the matter would be that the eye as an instrument is a remarkably efficient one, and not subject to fatigue, but it really is perhaps the attention that tires. If you look at something that is light, and there is a concentrated attention on a slight change, I think it is probably the brain molecule back of the eye that becomes tired. Perhaps the

* Part of a discussion of Prof. Geo. S. Moler's paper on this subject before the American Institute of Electrical Engineers. For the full text of Prof. Moler's paper see The Electrical World, May 30, 1891.

eye is capable of keeping up the record of images almost indefinitely, but back of that it depends almost altogether on the brain or the nervous structure—how light a thing is to be looked for and how often you do it in a given space of time.

Considerations Which Should Govern the Selection of a Rapid Transit System.*

BY PROF. GEORGE FORBES.

I know that there is always a general feeling over here that progress in electrical invention is retarded by the conservative spirit in Europe, that we are slow in taking up new things, and that you are very much further ahead than we in all electrical development. I think there is no one who is more ready in many cases to acknowledge that than myself, and frequently after my visits to this country when I have gone back I have been looked upon as a renegade for turning against our English methods of doing business, and for not supporting them, and for saying that you had been doing better in America than we were doing there. England has not in the past taken quite the position with electricity that she did with steam. She has not gone ahead and taken the lead in the world as she did with steam, neither in electric lighting nor in street railways. The reasons, however, for both of these are perfectly definite. Electric lighting was retarded in England owing to defective legislation which was introduced, and street railways would be working under different conditions in England from what they are now if it were possible to permit the overhead wires which we see in Boston and other cities of this country. If these could be permitted in London or other cities we would be, I venture to say, not far behind you in the progress of street railways in England. But there are such objections to it that that is impossible: and if you, on the other hand, were deprived of the advantages of the overhead-wire system for street railways you would be, I venture to say, as far back as we are at the present moment.

Now, however, we are coming to a new stage of electrical progress, and that is not of street railways, but of real rapid-transit railways, and there I venture to say that we have made a start ahead of the United States; that in the development of the South London Railway we have made a step of very considerable magnitude—not a step of considerable engineering magnitude, but a step of considerable magnitude in overcoming the inertia of the rest of the world—in leading capitalists, municipal authorities and the public generally to recognize that traction on a large scale is an accomplished problem. Mr. Sprague has given us a general idea of the problem as it exists now, and as the public are studying it, and has given us the most lucid account which I could conceive of the present position of the question of rapid transit considered generally. I think every one who has listened to his paper in all probability thinks that electricity is the only means which will be adopted.

I will now say a few words as to my own experience with the South London Railway so far as it seems to bear upon the problem here. The system is working with absolute perfection at the present moment. At the beginning of its running there were some little troubles, chiefly mechanical. There were no electrical troubles connected with the railway after they once got the proper engine down to work. At first an engine not quite powerful enough for all they wished to accomplish was put down, but that was soon replaced by a more powerful one, and now its service is as perfect as could be wished.

The comfort of traveling on this line is worth speaking about. I have noticed in talking with New York men that their idea is that an underground railway is necessarily objectionable. If those persons speak from experience of the underground railway—the District and Metropolitan railways—I must say it is the most perfect good sense. Traveling on that system is simply atrocious, especially in warm weather. But on the South London Railway the comfort is perfect, the temperature is uniform summer and winter. There are not the fumes that are in the underground railway in London. No sewage could possibly filtrate into it. It is at a distance below all sewers and sewer contamination, and the ventilation secured by having two tunnels, the one for going and the other for returning, is absolutely perfect. The arrangements for large elevators—hydraulic elevators—at the stations for carrying people to the surface of the ground are also perfect. The only point which strikes one as a little curious is that, besides the electric system for propulsion and the hydraulic system for the elevators, we also have the compressed air system for the brakes, tanks of compressed air being carried on the cars. It may be that an electric system of brakes might be harmonious with the other parts of the system, but I may assure you here that the comfort of traveling on that railway is perfect and could not be improved upon. The little noise there is is not in the least objectionable; nor would it be in a city like this, where we are accustomed to considerable noises without raising objection to them.

My own opinion is certainly in support of the view which Mr. Sprague has initiated, that the solution of the rapid transit problem in New York is by deep tunneling and electric traction. As to the particular method of electric traction I will not say anything about that at present. It is a mistake to suppose that there is only one system of electric traction which could be put on—that heavy locomotives pulling the train is the only way by which the problem could be solved. But out of the many ways which may be proposed I feel sure that from the engineering ability which will be called in to discuss the question and to arrange the plans the outcome will be satisfactory. I have very great confidence that the problem of rapid transit in New York will be solved before many years in the way which electrical engineers wish it to be solved.

* A part of the discussion of Mr. F. J. Sprague's paper on this subject before the American Institute of Electrical Engineers. For the full text of Mr. Sprague's paper see THE ELECTRICAL WORLD, May 30, 1891.

The Future of the Aluminium Problem from a Chemical Standpoint.*

Dr. LEONARD WALDO: Aluminium is a material of structural engineering, and the conditions of its work must conform to those ideas which belong to the shop and seldom belong to the laboratory. If our mills accept the specifications from some men who know about copper wire we are required to guarantee that the copper shall have a conductivity of 98 per cent. If we accept the specification for part of a machine of electrical engineers we require that they shall have certain physical peculiarities, and the materials which go into our work are sent to the laboratory, and we find that our bank of tin is .99 and .90 and .92. We find our copper is .998 and .999—sometimes it is over 100 per cent of purity. We find that the zinc we use has the same qualities. Our works were built at the beginning of the aluminium era, and we did not stop to think that aluminium was aluminium, and we bought freely. We bought many thousands of dollars' worth of metal. Then we began to learn our lessons afterward. We took the books and papers from the laboratories, and they said nothing was simpler than to cast aluminium bronze, and we proceeded to do that very simple thing of casting aluminium bronze, and we poured more metal down holes than any concern in the United States. We poured it down systematically, and got uniform results. We read the books again, and they said it was a very easy thing. Here are some of the results (showing some spongy samples). Here is a section sawed right out of the inside of a propeller wheel for the United States government. We were going to give them 60,000 pounds to the square inch on a direct pull, and we were going to realize a fortune by building all the propeller wheels for the navy. It was poured carefully as the books direct—bottom poured, as the books direct—and that was the result. Nobody knew why. One of the head casters thought the metal was poured too hot, and another thought it was poured too cold, and another said it was not poured right. But the work came back and we began to learn about aluminium, and we discovered that there is one thing necessary—that is, that the experience of past centuries cannot be safely ignored because aluminium is a new metal; that if you get silicon and put iron and put all the by-products of a furnace into your silicon, you are getting a good result every time. I never knew nature to make any mistake in any of her experiments.

Now the condition of the aluminium problem is this: We have got two corporations in the United States distinguished by the beauty and the energy of the work which they are producing. The U. S. Government, with a sharp eye to the encouragement of all new industries, has promptly put a tariff on aluminium. The two companies immediately got into lawsuits, and a judge of the court decides what the price of aluminium shall be. It takes a bright man to predict that a new process is going to be discovered; so that in the present condition of affairs I do not know but that the estimates that we have listened to are of very great value to us, because all of the processes depend on the chlorides, depend also on the cost of acids in this country as compared with their cost in England, and while the estimates are quite correct so far as the cost of steam and that sort of thing is concerned, the price is still maintained in the United States. But we would not care so much for the price if we had the quality. Here, (showing a specimen) is a bar broken at the United States Watertown Arsenal machine. It is made of a nice aluminium of over 99½ purity. It is fatigued the whole length. It behaves just as the material you and I want to use in structural engineering should behave. The same percentage, high in silicon, gives this result (showing), broken short off; a small expansion from breakage strains and the metal generally short and sharp for use. Here are as large sections as I could bear to bring down here of heavy castings where the metal has been turned and sawed in order to show the structure of the metal. That is a 10 per cent. bronze, which, you see, is perfectly solid. A part of the section is left here entire that the section may be shown out of which the whole of the metal is made. That, of course, is the king of bronzes. There is no known material, except steel of extraordinarily good quality, which will give you the economical values aluminium bronze gives you. Here is the same style of casting, but showing the effect of improper work in the casting of the metal in the blow-holes which come under the risers. This metal is perfectly sound otherwise, but under the risers are these blow-holes, which unfit it for the particular work for which this was designed. These results are extremely important, because under a proper manipulation of the bronze it is possible not only to give metal castings which are absolutely non-porous, which will stand any pressure up to several thousand pounds to the square inch, but it is possible to give them strengths running from 90,000 to 100,000 per square inch in the casting. But I have taken pains to come this afternoon, because some one from the standpoint of the engineer must put on record a distinct and emphatic protest against the use of an alloy called aluminium. It simply cannot be used to get definitive results. I mean it canot be used in our practice.

Now to come to the important application of aluminium bronze. Aluminium, as you quite well know, probably has a conductivity equal to copper, bulk for bulk, and it has 2½ or 3 times the conductivity of copper, weight for weight. I am speaking now of aluminium which is free from silicon and from iron. *A priori*, therefore, it is the best-known metal for alloying with copper in order to give copper the structural strength necessary for all forms of electrical engineering. But here the impurities of silicon and iron come in with a particularly damaging effect. The conductivity of the alloys of aluminium and copper as ordinarily made bear no relation whatever to the proportional bulk of the metals themselves.

I cannot say much on this question, because it is a question which is being very carefully investigated in our own laboratory. But that is true, and until the producers of aluminium bring the aluminium product over 98, 99, or 99.9—the nearer they come to it—the electrical engineers have got to be content with quite a low order of conductivity, both in all sorts of places where metal is applied and in their wires where they want strength, and expect to get the conductivity, but fail. The present position of the aluminium bronze is very closely akin to the early years of steel. I heard a question asked of a famous chemist as to whether he could determine the carbon in steel. He said: "Do you really mean that?" "I do," was the answer. The chemist said: "I cannot." Now the analysis of copper is in its infancy. I doubt whether a man could rely on the determination of copper. But the moment you add aluminium and silicon to copper the question is immensely complicated. The first real work, therefore—now that we have a reasonably pure supply of aluminium, or that we can expect to get a reasonably pure supply of aluminium—is to be done on the scientific side of the question. We have got to have accurate methods of analysis, and we have got to have a great deal of work done on the mixture of copper and pure aluminium, and of aluminium as we get it chemically united with silicon and with iron. The color of the bronze is a royal color. It is merely dipped in nitric acid to get out all the color, and you will get an idea from dipping it what the strength and general value of the metal is.

Prof. F. B. CROCKER: In regard to the conductivity of an alloy, I should doubt very much if the average conductivity of its constituents, or any approximation to it, could be expected. For example, pure silver put into copper will very seriously interfere with the conductivity, and pure silver is supposed to be better than copper in conductivity. That seems to be a fatal fact about the conductivity of alloys, that any alloying seems to reduce conductivity very seriously, and the smallest percentage of alloy or impurity—whatever you might call it—has a very great effect upon a reduction in conductivity; and this seems to be true no matter what metals are put together.

Dr. WALDO: Of course, in discussing all these alloys, the best conception to have is that the alloy is a glass rod transparent to electricity. The oxides and other things which come in and which are precipitated and act as chemical stains stop the flow of the current, and whether or not the pure aluminium and the pure copper obey that law of disproportionate conductivity is a question which I think no man can pronounce on, because I do not think any man has ever tried it. A great many people have mixed the aluminium and copper and determined the conductivity of the result, but that is a very different thing.

Prof. F. B. CROCKER: If it is a fact that aluminium bronze or alloys of aluminium and copper or other metals can be made having a conductivity approximating the mean of their constituents, it would certainly be a valuable thing in electrical engineering, a thing greatly to be hoped for.

Mr. WESTON: I have used aluminium quite extensively. I think Dr. Waldo is mistaken about its conductivity. I have found it to be 60 per cent. that of copper. There is very little variation in the various samples I have met with, and that is about the average figure. Of course I think what Dr. Waldo says about the action of small quantities of silicon or iron in aluminium when mixed with copper, to form an alloy, may have a very marked influence upon the conductivity and working of the alloy. Silicon has a very marked influence on the working qualities of steel, and I think also on the conductivity. There is another matter there that probably might be worthy of investigation, it appears to me. The copper of commerce is commonly assumed to be extremely pure, and within the past few years there has been a quality of copper called tempered copper put on the market, which analysis shows to be substantially the same as good Lake Superior copper. But when you examine it for conductivity it has about 60 or 75 per cent. of

* Part of a discussion of Dr. W. H. Wahl's paper on this subject before the American Institute of Electrical Engineers. For the full text of Dr. Wahl's paper see THE ELECTRICAL WORLD, June 6, 1891.

the conductivity of good Lake Superior copper. Now it has occurred to me that the tempered copper, which is produced by a secret process, so far as I know, is probably a mixture of copper and hydride of copper, which was discovered by Wurtz some few years ago, and is nearly as brittle as glass. A very small percentage of that hydride of copper added to copper would have a very marked influence, I should think, on the physical and electrical properties of copper. An analyst, unless he made a very careful examination of the copper, would be likely to miss such a thing as a small quantity of hydrogen or hydride of copper, and hence the published analyses of this tempered copper, of which we have heard a great deal, have not been made, probably, with sufficient care to detect a minute trace of hydrogen or hydride. That is a field probably well worth exploring to find whether the hydride of copper, which is very probably formed in making copper, does not come into play here, both in the working properties and in the resistance of the alloys or of the metal itself.

Dr. Waldo: I would like to say that my own best determination of the conductivity of the best aluminium I could get was .6604, but I never have seen a piece of aluminium which was higher than .9903. I have had a number of samples submitted to me which by perfectly easy analysis have run as high as .9975 and .9908. But a rigorous analysis has always reduced the amount of the purity of the aluminium. I doubt extremely whether any ordinary samples of aluminium which you would handle would run to .99. My personal judgment is that the conductivity might run very close to that of copper itself, and there has been no evidence on record that I know of which would tend to disprove that, and a good deal of our private work in our laboratory would go to show it.

Electric Meters.*

Prof. Elihu Thomson: I am a little at a loss to know just exactly what we have under discussion, whether it is the meter which is before us or the various meters that are mentioned in the paper. If I look upon the matter in the broadest way I might perhaps be able to say something as to each type of meter mentioned. But that would be rather a lengthy procedure, and, as one form of meter which I have designed is mentioned, perhaps I had better confine my remarks principally to that. In the first place, Prof. Forbes made a very apt remark in connection with this meter, and that is that it ought not to be called a wattmeter, which is perfectly true. "Watt" simply indicates a rate. But it is not called a wattmeter. It is called a *recording* wattmeter; that is, it records the rate and integrates the rate for the time. The paper before us speaks of this form of the meter, which, by the way, of course, has been designed for a certain purpose, to fit certain conditions. One of those conditions was to give the customer an opportunity to read for himself just as he does with the gas-meter record, and to understand it. That we found in a good many cases an important matter, and our efforts were spent largely to secure that end—to get, as it were, an instrument that would represent the gas meter recording on a dial the use of current. The instrument, of course, has its limits—that we must fully recognize; but that it does good service inside those limits, perhaps, is also perfectly true. It will of course not readily respond to 1 volt or to 10 volts perhaps, but it will respond to conditions of considerable variation in the voltage, as well as enormous variation in the current. Such meters have been constructed that will range from 1 to 200 ampères, which of course is quite a wide range, and varying only a half of one per cent. on the lighter load. The accuracy for the heavier loads is almost exact—as exact as such mechanism could be expected to be. The accuracy for the smaller load meters is all that could be desired. The sensitiveness is of course considerably less than one ampère. It sometimes goes as low as a quarter of an ampère. Now, this matter of the range which a meter can work under is of course an important one; and I know no type of meter which has given so much range with the same accuracy. It is true that the principle of the meter is not new. I claim nothing especially for the principle. I simply claim the working of that principle into a device which is useful in the industrial applications. There are features about the meter which did not appear in any former arrangements; and these features, I think, have made it a success. The same criticism might be made on the meter before us†—that the principle of it is not new. The new feature, perhaps, is the recording by a photographic method as distinguished from recording by other methods. I remember distinctly, in, I think it was, 1886 or 1887, making a meter which was substantially the same in principle, only the record was made on a sheet of paper by punching little pinholes at intervals. The friction was as little as it is in the meter before us, and the little point that passed over the paper was clear of the paper until an electromagnet struck it a blow and made a little indentation, the point jumping up again and being ready to take a different position. That eliminated the element of friction, and I had in that meter an arrangement for doing away with clockwork which worked very satisfactorily. It is nothing more or less than a pendulum which is self-starting. There was an electromagnet which pulled upon an armature, and a pendulum self-starting. This depending lever of the pendulum was pivoted, working a pawl, which gave us the motion of winding for the paper. The pendulum at rest was always stopped in a position ready to start, and it broke its own circuit, worked the set of contacts, and the magnet kept the pendulum in motion, so that our rate was perfectly regular. The little point was mounted on a spring connected with the ammeter, which was merely a little piece of iron on a vertical shaft inside a coil, and the coil and iron shaft so arranged as to get substantial uniformity throughout the whole length. This little point was over the strip of paper, and the electromagnet hammer at every revolution of this ratchet wheel, which constituted practically the whole of the clockwork, struck a blow on the paper giving a mark. The record on the paper as it came off would be a series of dots, and these would change according to the load. The same process of integrating this curve would be used as in the meter before us. For this purpose we did not waste any energy as here used in working an incandescent lamp for the meter. No doubt the lamp could be diminished in size. But if it should give out from any cause it is not replaceable at once. Unless some one discovers the difficulty the record fails. I do not care to go into any further criticism in relation to this matter; but I think when we look at those things we should be prepared to look at them from all sides.

Mr. G. W. Walker: The remarks of Prof. Thomson are undoubtedly very explicit and very true. The principal criticism that has been made on the Walker meter is a very good one, namely, the possibility of the breaking of the lamp. But while in this case you see a lamp burning very brightly, the candle-power used there is not at all necessary. If the possibility of breaking the lamp should prove to be a serious objection, it is very readily overcome by putting in a double filament or a contrivance for two small lamps. The mechanism and the power required to operate it depends entirely upon the size of the wire on the magnet for winding the clock, and, as I said before, the candle-power of the lamp is of very slight consequence.

Mr. Edward Weston: The form of meter having the dial seems to me to have a great many very marked advantages over any other type of meter known. In the first place the public are more or less acquainted with the gas meter. One can make note of the changes on the dial and have a check upon the gas company, assuming, of course, that the meter is moderately correct. On the other hand, a system of metering which does not enable the consumer to check the results—to check the consumption—seems to me to be open, at least, to some objection, possibly considerable, and even suspicion on the part of the consumer. Hence you can readily understand why so much time has been spent in endeavoring to bring that type of meter closely approaching the gas meter to the state of perfection to which it has been brought to-day. The type of meter before us to-day has certain excellent features, and is certainly a very ingenious piece of mechanism, and, I have no doubt, will record quite accurately. It is free from a great many difficulties and defects that exist when the record is accomplished by mechanical means. The recording mechanism does not introduce any friction. But it has, of course, the disadvantage that the record must be taken back to the station house and be developed. It is true that that record can be produced at any time for the inspection of the consumer in case of dispute; so it might be said to be proof positive of the correctness of the bill rendered. But it seems to me that it would never be accepted with the same degree of confidence that it would if the consumer could make those calculations, and did make them himself—kept a real check on the meter. It has to go out of his hands to be developed, and unless he has a person to see that it is developed he might readily charge fraud on the part of the company supplying current. I have had occasion to examine the Thomson meter, and I am inclined to give the man credit for working out the details of the appliance and getting it to the state of perfection to which he has brought it. It means a good deal of hard study to bring appliances of that kind to a condition where they can be used practically and trusted perfectly; and while some one else may have conceived the idea, too, let us give the man who has brought the thing to a state of perfection credit for that. The objection to the clockwork is of course its first cost. The most accurate meter I have ever seen in my life was the Aron meter, but it requires a little more skill than we generally meet with to set it up, and it requires considerable skill to adjust it so as to get it to yield good results. It will yield admirable results if handled correctly—better than any meter I have ever seen. There has been some discussion about voltmeters, and that introduces a subject which is somewhat interesting to the members here. It is generally supposed that in recording voltmeters friction would be the principal loss of power. Now, that is not so. I think you can get the recording voltmeter with recording measurement so perfect and so simple in character that you may say that you can practically eliminate friction from that part of the apparatus. The temperature changes are very frequently overlooked, and they frequently amount to a very large sum indeed. They can be compensated for to a certain extent, and possibly, as we gain more experience, perfectly so. But there is a good deal of misconception about that question of compensation of instruments. A short time ago I devised a little apparatus for compensating for change in temperature, which consisted substantially in a little thermometer, the bulb of which extended over the coil of the instrument so as to indicate its temperature. The thermometer bulb is supposed to be small; and although the instrument, as actually made, was not as small as it should have been, it responded very readily to slight changes in the temperature of the coil. To avoid any computations I put on a little device by which you could turn an index around to a point corresponding to the temperature indicated on the thermometer; that is to say, if the thermometer showed 75 degrees, then you would turn the indicator around to a point indicating 75, and you compensated without any calculation whatever. One of the published criticisms on this device overlooked one important thing—that you might compensate for air changes readily, and yet not compensate for changes produced by the heating effect. Now, to get an instrument properly compensated you must compensate for both things—changes in the instrument itself due to changes in the atmosphere, and changes caused by the actual passage of the current. It frequently happens that criticisms and remarks are made about the operation of an apparatus which are wholly unjustified and untenable upon a close study and examination of the things themselves. I think this same is true of the Thomson wattmeter. I have had occasion to listen to a good deal of talk about the Thomson wattmeter. Some of it has been of a pretty severe character and the instrument has been severely criticised. Now, I do not think the instrument was so much to blame as the parties who were using it. I am frank to say the examination indicates no such errors as they speak of unless it is abused in some way. In the Thomson instrument I do not think the proportions are the best imaginable to get the very best results. But I think it is only a question of time when they will make quite important changes in detail which will make it far better than it is to-day. One criticism I should make is that the moving parts were somewhat heavy and they should be reduced in weight as much as possible. That can be done by the substitution of aluminium for copper on the retarding device, that is, on the disc. The form of the retarding device might be changed. Instead of adopting a disc an inverted cylinder might be used running between the poles of a powerful magnet, and you might get exactly the same retarding effects by bringing the poles very close together, having a central core, and thus reduce the weight very much. I should be very much afraid of errors creeping in from the mass of matter to be acted upon there by the current, especially with low loads. I should not think much of it with heavy loads. But with small load and few lamps—say three or four—I should be afraid that the friction on the pivot would not be a constant element. I do not think that is anything against the instrument, because I think it can be entirely overcome. The Thomson instrument, of course, has the advantage that it can be used for either alternating or direct currents.

Prof. Elihu Thomson: I think Mr. Weston has shown by his remarks that he has spent a good deal of thought on this very problem and understands the conditions most fully. It is not an easy thing,—and I can say it after considerable experience,—to get just exactly the desired results at the first. You may make a laboratory apparatus as perfect as possible and put it out into commercial use and you will find difficulties. It is not until you have had commercial experience that you can make those little refinements which are shown to be absolutely necessary. Mr. Weston has said very truly that the weight of the parts in the meter as constructed by us has been rather heavy. We are making every effort to reduce it. We are using much lighter discs and getting as strong as possible a field for the retarding disc to move in. It is not a case of getting a meter that will measure the current, but it is the case of making a thing that will not cost too much. You may have a very fine mechanism, you may have an excellent device for the purpose, but if it costs $50 nobody will take it. You must be able to make it for $7 or $8. I hope to be able some day to make a good meter for $3 or $4. When we have done that I shall consider that the meter question is probably laid aside. But it is one of those questions that has been with me for a long time. I have had no problem that has demanded more time, care and attention. I would much prefer to design a thousand horse power dynamo and see it through than to do the same thing for a meter.

* Part of a discussion of Mr. George W. Walker's paper on this subject before the American Institute of Electrical Engineers. For the full text of Mr. Walker's paper see The Electrical World, May 30, 1891.

† The Walker meter.

World's Fair.

Contracts have been let for the construction of the Electricity Building. The successful bidders and the amounts of their contracts were as follows: Carpentry and iron work, Arthur Johnson & Bro., of Omaha, $164,444; staff work, Park & Bates, Chicago, $85,000; painting and glazing, W. P. Nelson & Co., Chicago, $6,522; lathing and plastering, John Griffiths, Chicago, $6,000. Awards were not made for the roofing, as the construction department desires to make a private test of the material submitted by contractors for that purpose.

Some Effects of Alternating Current Flow in Circuits Having Capacity and Self-Induction.*

BY DR. J. A. FLEMING.

Let $R = 10$ ohms, and $L = 200$ henrys--values possible to be reached in practice—then, if C is measured in microfarads, we see that that $(1 - C L p^2) + C^2 R^2 p^2$ becomes

$$\left(1 - \frac{C \times 273{,}947 \times 200}{10^6}\right)^2 + \frac{C^2 27{,}394{,}700}{10^{12}} = (1 - 55\,C)^2 + .00003\,C,$$ nearly.

If C is absolutely zero, the value of this quantity is unity. If C is equal to 1-27th of a microfarad, this quantity is

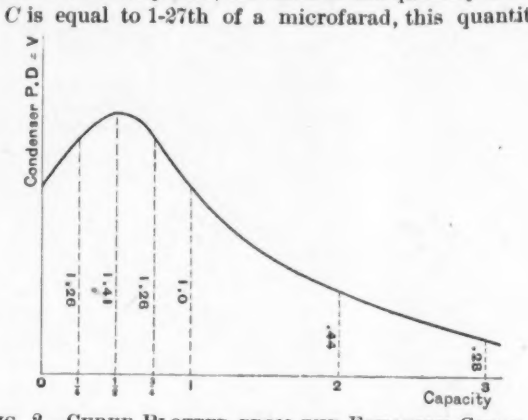


FIG. 2.—CURVE PLOTTED FROM THE EQUATION GIVEN IN SEC. 7.

also, roughly, equal to unity. If C has any value between zero and 1-27th of a microfarad—say 1-50th of a microfarad—then, since $\left(1 - \frac{55}{50}\right)^2 + .00003\,\frac{1}{50} = .01$, nearly, we see that the ratio of V_0^2 to V_1^2 will be 1 to 100, or V_1 will be ten times V_0. Hence it is obvious there is a narrow range of capacity within which the pressure at the condenser terminals may be enormously increased over that at the machine terminals; but if the capacity is altered so as to take it outside these critical limits, the so-called resonance effects will vanish.

The best way to see how the value of V_1, or the condenser potential, varies with variation of the capacity, other quantities being constant, is to plot the equation,

$$V_1 = \frac{V_0}{\sqrt{(1 - C L p^2)^2 + C^2 R^2 p^2}},$$

or—which comes to the same thing, and is simpler to plot --the equation,

$$y = \frac{1}{\sqrt{(1 - x)^2 + x^2}}.$$

This has been done in Fig. 2, and a curve representing the variation of V_1 in terms of C, or of the condenser plate potential difference in terms of its capacity, supposed variable, is there drawn, on the assumption that V_0, L, R, and p^2 have certain constant values. We see that the curve ordinate has a maximum corresponding to a certain capacity, and that beyond that point increase in capacity continuously diminishes the condenser plate potential difference.

The condenser effect will be at a maximum when C and L have such magnitudes that $C L p^2$ is unity, and C has at the same time a small value. In this case V_1 may be hundreds or thousands of times greater than V_0. In testing condensers with alternating current machines, it is very important not to have that particular critical relation between C, p, and L, or the capacity, frequency, and inductance of the machine which will bring about the resonance effect, or else the testing process may be a destructive process as far as the condenser is concerned.

8. Quite similarly, we can show that if the capacity of the condenser is fixed, there is a certain range of inductance of the circuit of the alternator within which the resonance effect takes place. For example, let $C = .1$

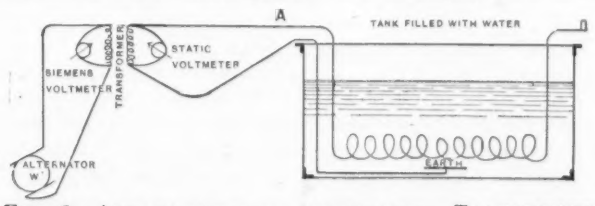


FIG. 3.—ARRANGEMENT OF ALTERNATOR, TRANSFORMER AND CABLE IN EXPERIMENTS MADE AT MESSRS. SIEMENS' WORKS.

microfarad, as before, $p^2 = 273{,}947$, and $R = 10$ ohms, then for the ratio of V_0^2 to V_1^2 we have the value

$$\left(1 - \frac{273.947\,L}{10^7}\right)^2 + \frac{273.947 \times 100}{10^8} = (1 - .027\,L)^2 + .27.$$

If $L = 0$, this ratio is greater than unity; if $L = 74$, the ratio is again greater than unity; but for values of L between 0 and 74, the ratio is less than unity. In other words, within these limits of the inductance the pressure at the poles of the condenser is raised.

The above theory is shown to be confirmed in its general character by the results of some highly interesting experiments, made more than a year ago (April 10, 1890) at the works of Messrs. Siemens Bros., which Mr. Alexander Siemens has sent to me. A Siemens W_1 alternator was kept running at a constant speed of 750 revolutions, and the exciting current was also kept constant. The current from this was sent into the thick-wire coil of a No. 2 transformer. The terminals of the fine-wire circuit were connected to various lengths of single conductor cable, having gutta-percha insulation and immersed in a tank, the cables being insulated at the far ends, and forming thus a condenser attached to the secondary of the transformer (see Fig. 3). The pressure was measured at the terminals of the machine, and at the terminals of the transformer on the secondary, or condenser side. The experiments consisted in varying the length of the cable used so as to vary the capacity, and in observing the pressure at the two sides of the transformer while the dynamo was kept running at constant speed and excitation. The results are embodied in the following series of interesting curves. The horizontal distances in the diagrams represent the various capacities of the open-circuit cables or condenser attached to the terminals of the secondary of the transformer. The vertical ordinates in Fig. 4 represent the observed potential difference of the two surfaces of this condenser—that is, the potential difference at the secondary terminals of the transformer.

It will be seen from Fig. 4 that when the capacity is zero this potential difference was 2,500 volts. As the length of cable was increased continuously, this potential difference rose up to 8,500 volts, corresponding to a capacity of .2 microfarad, and then fell again to 2,500 volts, at a capacity of .45 microfarad. Hence, corresponding to a certain

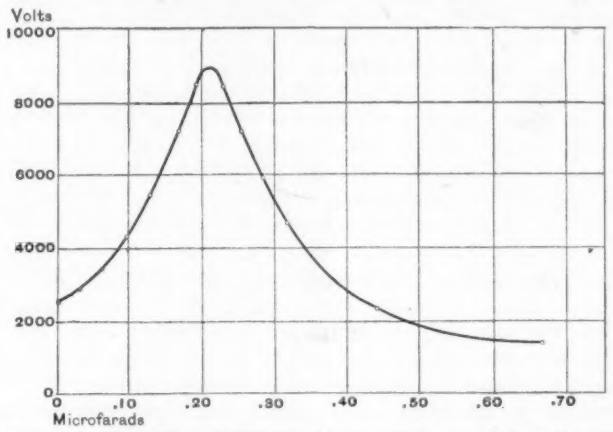


FIG. 4.—CURVES SHOWING VARIATION IN VOLTAGE IN SECONDARY (HIGH VOLTAGE) CIRCUIT BY VARYING CAPACITY IN SECONDARY (HIGH VOLTAGE) CIRCUIT.

The experiments have been made with a No. 2 transformer, and current was obtained from W' machine, frequency being 100 periods. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

capacity—viz., .2 microfarad--the pressure is multiplied about 3½ times, and there is a certain narrow range of capacity over which this exaltation of pressure takes place. At and beyond .45 microfarad capacity, the presence of the condenser reduces the normal pressure continuously. The pressure on the primary side of the transformer is also increased, as shown in the curve given in Fig. 5, which represents a series of similar pressure observations taken on

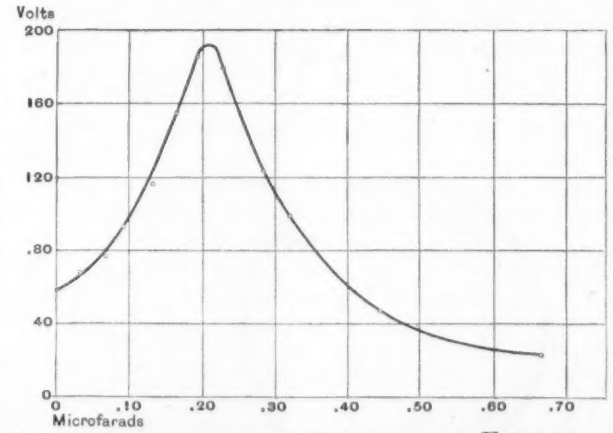


FIG. 5.—CURVES SHOWING VARIATION IN VOLTAGE IN PRIMARY (LOW VOLTAGE) CIRCUIT BY VARYING CAPACITY IN SECONDARY (HIGH VOLTAGE) CIRCUIT.

The experiments have been made with a No. 2 transformer, and current was obtained from W' machine, frequency being 100 periods. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

the primary side of the transformer. It will be seen that the same general effect takes place on the primary side. It will be seen how entirely these curves deduced from observation agree with the theory as illustrated by the curve in Fig. 2. The curves in Figs. 4 and 5 are generally similar, but, if superimposed, will be found to be not quite so. If the ratio of corresponding ordinates is set off so as to form a fresh curve (Fig. 6), this curve will give the variation of change ratio of the transformer corresponding to the various capacities, and we see that this change ratio is altered progressively from 1 : 43 to 1 : 57, as the capacity of the condenser on the secondary is changed from zero to .65 microfarad. It is evident, therefore, that in applying transformers to test cable, such as concentric cable, which possesses sensible capacity, we must be on our guard against this alteration of the change ratio of the transformer, or else we may be misled as to the real pressure being applied to the cable.

9. These considerations point out that, in applying either transformers or alternators to circuits which have capacity, we must have regard to the fact that, for certain critical values of the inductance and the capacity for given frequencies, there may be a very considerable increase in the potential difference of the two sides of the condenser over and above that of the poles of the alternator or transformer when no condenser is present. Such effects have been noticed in practice of late. It has been frequently found that, if a transformer which gives on its open secondary circuit a certain potential difference is applied to test the insulation of a length of concentric cable by connecting its terminals to the two conductors, the far ends of the cable being insulated, under some circumstances an increased potential difference is observed between the free ends of the cable over and above that at the terminals of the transformer when the cable is not connected to it. When transformers have been employed to test the insulation of armatures of high-pressure alternators, it has been noticed that under some circumstances large snapping sparks will jump off over air distances which could not possibly permit discharges

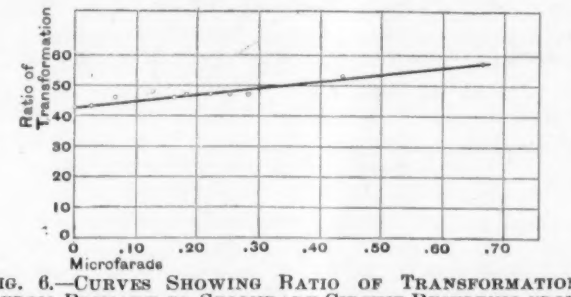


FIG. 6.—CURVES SHOWING RATIO OF TRANSFORMATION FROM PRIMARY TO SECONDARY CIRCUIT RESULTING FROM FIGS. 1 AND 2.

at the actual potential difference of the secondary terminals of the transformer so used when unconnected with any such body having capacity.

In employing an alternator or transformer to test insulation between two opposed conductors, or in any way in which the opposed terminals gain capacity, it is necessary to be on the watch for this possible rise of pressure, and not to infer, because a transformer gives, say, 2,000 volts on open circuit between its poles when measured with an electrostatic voltmeter, that therefore this is the measure of the pressure which is being applied to a dielectric which forms the insulator of a condenser joined in across the poles of that transformer.

I am not at all sure that under some circumstances errors may not be committed in the mere use of an electrostatic voltmeter to measure potential difference between the poles of an alternator or a transformer if that voltmeter happens to possess a certain capacity in relation to the inductance of the circuit in which it is joined in parallel.

10. It is easy to treat in the foregoing manner another case slightly more complicated.

Let the inductive line $a\,b\,g\,f$ (Fig. 7) be divided into three sections, $a\,b$ and $b\,g$ having each resistance R and inductance L, and the section $g\,f$ having r and l for similar quantities. Let condensers of capacity C be inserted in b and g. If v and v_1 are the potentials at any instant of the condenser terminals, and i, i_1 and i_2 the instantaneous currents in the sections of the line, and i, i_1 and i_2 the maximum values of these periodic currents, it is not difficult to show, with our former notation, that

$$v_1 = \frac{I}{Cp}\Big((Ba + Ab)\sin pt + (Bb - Aa + 1)\cos pt\Big); \quad (21)$$

but

$$i_2 = i_1 + C\,\frac{dv_1}{dt},$$

and

$$i_1 = I\,(a \sin pt + b \cos pt) \quad (22)$$

by (12). Hence we have

$$i_2 = I\,\Big\{(Aa - Bb + a - 1)\sin pt + (Ba + Ab + b)\cos pt\Big\}, \quad (23)$$

from which we deduce that the ratio of the maximum currents I_2 and I_1, in the first and second sections of the line, is given by equation,

$$I_2 = I\,\sqrt{(A + 1)^2 + B^2)\,(a^2 + b^2) + ab\overline{A - B} - 2a\overline{A + 1} + 2Bb + 1}, \quad (24)$$

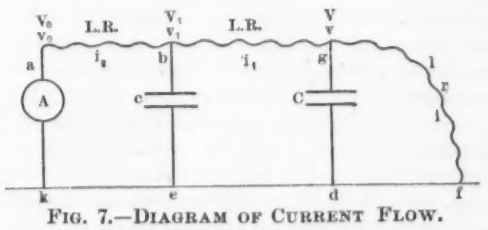


FIG. 7.—DIAGRAM OF CURRENT FLOW.

and in like manner the ratio of the maximum values of the potentials V_0 and V_1 can be obtained.

It is possible also to show that for certain critical values of L, C and R the potentials V_0, V_1 and V at the terminals of the alternator and at those of the condensers progressively increase, as well as the currents in the sections of the line. Cases of this kind, beyond a single condenser, are best treated as Mr. Blakesley has done—by geometrical methods.

11. In the limited case of a condenser charged by an alternating electromotive force through an inductive circuit, we may arrive at a direct analytical solution of the relation between the coefficients of induction and capacity of the system and the mean square of the charging current, and of the potential difference at the poles of the condenser or at those of the alternator, as follows: As before, let V_0 and v_0 stand for the maximum and instantaneous values of the potential difference at the poles of the alternator; let V_1 and v_1 be the same quantities at the terminals of the condenser; and let I and i be the same for the current flowing into th

* Continued from THE ELECTRICAL WORLD, May 23, 1891.

condenser having a capacity C, while the line connecting the condenser with the alternator has an inductance L and a resistance R. We have, then, by fundamental equations, the following relations:

$$L\frac{di}{dt} + Ri = v_0 - v_1, \qquad (25)$$

$$i = C\frac{dv_1}{dt}. \qquad (26)$$

Also, let $v_0 = V_0 \sin pt$, and hence

$$i = I \sin (pt + \theta),$$

where θ is the angle of lag of current behind the impressed electromotive force.

Eliminating v_1 from the above equations we have,

$$L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{i}{C} = pV_0 \cos pt, \qquad (27)$$

or, since, for simple periodic currents, $-p^2 = \frac{d^2}{dt^2}$, we have

$$\frac{di}{dt} + \frac{1 - CLp^2}{CR}i = \frac{pV_0}{R}pt. \qquad (28)$$

This equation is of the form,

$$\frac{di}{dt} + Pi = Q \cos pt,$$

the solution of which is known to be

$$i = \frac{QP}{P^2 + p^2}\cos pt + \frac{Qp}{P^2 + p^2}\sin pt;$$

and an easy transformation gives us, therefore, the solution for the particular case in hand as

$$i = \frac{(1 - CLp^2)\cos pt + CRp \sin pt}{(1 - CLp^2)^2 + C^2R^2p^2}CpV_0. \qquad (29)$$

This can be written also,

$$i = \frac{CpV_0}{\sqrt{(1 - CLp^2)^2 + C^2R^2p^2}}\sin(pt - \varphi), \qquad (30)$$

and the maximum value of i, viz., I, is therefore

$$I = \frac{Cp}{\sqrt{(1 - CLp^2)^2 + CRp^2}}V_0. \qquad (31)$$

This gives us the mean square, or dynamometer, value of the current I flowing into the condenser in terms of the mean square value of the potential difference of the poles of the alternator and the coefficients C, L, R and p. If $CLp^2 = 1$, then the value of I reduces to $\frac{V_0}{R}$; in other words, for this particular value of the relation between the inductance and the capacity, the whole system of inductive charging line and condenser acts as if it were a non-inductive conductor of resistance R.

We see also that this equation (31) can be made use of to determine L from observed values of I_1, V_0, C, R and p, or else C when L is known. The value of the mean inductance of the line is given by the equation,

$$L = \left(\frac{1}{Cp^2} - \frac{1}{p}\sqrt{\frac{V_0^2}{I^2} - R^2}\right) \qquad (32)$$

which gives L in terms of observable quantities.

The current at any instant flowing across the dielectric of the cable may be spoken of as the *condenser current*. It is always in magnitude equal to the product of the capacity of the condenser and the time rate of change of the mean potential difference, v_1, of its surfaces. It follows that in the case of simple periodic currents the square root of the mean square of this current I, which is what we measure with a dynamometer, is equal to the product of the square root of the mean square of the condenser plate potential difference V_1, and the quantity Cp, where C is the capacity of the condenser, and p, as usual, is 2π times the frequency, or $I = CpV_1$. This follows at once from equations (19) and (31). The value of the potential difference at the terminals of the condenser, as measured, say, by an electrostatic voltmeter, is therefore determined by the magnitude of the condenser current flowing into it, as measured by a dynamometer when the frequency of the current is known.

12. The writer witnessed some experiments made in the Standardizing Laboratory by Major Cardew, in which the above measurements were carried out. A condenser of .5 microfarad was joined across the poles of an alternator, a Thomson deciampère balance was put in the charging circuit, and a Thomson multicellular electrostatic voltmeter across the terminals of the condenser. The readings of the voltmeter, V_1, and of the ampère balance, I, were taken simultaneously, with the following results:

Frequency of current, n.	Volts across condenser poles, V_1.	Charging current in ampères, I.	
		Observed.	Calculated.
103	360	.132	.116
103	396	.145	.128
103	493	.175	.160
103	583	.200	.189
90	481	.150	.136
90	598	.187	.170

For the frequency $n = 103$, $p = 2\pi n = 647$, and for $n = 90$, $p = 565$.

Hence, since the condenser capacity $C = .5$ microfarad $= 5 \times 10^{-7}$ farads, we have as the values of Cp for the respective speeds $3{,}235 \times 10^{-7}$ and $2{,}825 \times 10^{-7}$, and the values of the condenser current are calculated from the relation $I = CpV_1$. The calculated values of the currents are all lower than the observed, and in about the same ratio, viz., about 10 per cent.; but the speeds of the alternator, and therefore the current frequencies, were not known with a degree of accuracy sufficient to enable it to be determined how far the agreement of observation with theory is complete.

13. The relations between the capacity and self-induction necessary to bring about an increase of pressure at the condenser terminals, when an alternator charges a condenser, are well displayed by the use of a clock diagram of electromotive forces. Such diagrams have been given by Mr. Kapp in some recent papers, and the particular one here given is practically the same as one given to me by Major Cardew, who has also examined this particular problem. The following mode of regarding it will be found to be an easy one. Construct a clock diagram of electromotive forces (see Fig. 8) for the simple case of a condenser charged through an inductive line by a constant harmonic impressed electromotive force. Lines drawn radially from a point O in Fig. 8 represent the maximum values of various electromotive forces. Let OV_0 be the maximum value of the impressed E. M. F. at the dynamo terminals, and OC that at the condenser terminals, I the maximum current in the line. Take any line OR to represent the effective E. M. F. in the line, and therefore equal to the product RI, where I is the current charging the condenser, and R is the resistance of the line. From R draw RL at right angles to OR, and let RL be set off equal to LpI; L being the inductance of the line, and p being, as usual, 2π times the frequency of the current. Note that when a quantity varies harmonically the product of p and its maximum value give us the maximum value of its time rate of change, or time differential, while the quotient of its maximum value by p gives us the maximum value of its time integral. Accordingly, OL, which is made equal to LpI, represents the counter electromotive force of self-induction, or back E. M. F., in the line as far as is due to its own inductance, and is in

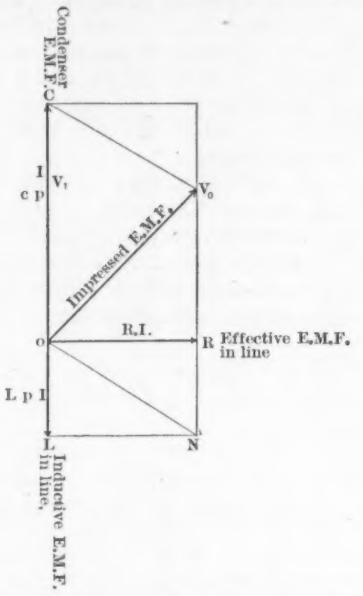


Fig. 8.—Diagram of Electromotive Forces.

quadrature with RI as regards phase. Hence the resultant of these two is ON. Next set off OC at right angles to OR, and in advance of it, and make OC equal to $\frac{I}{Cp}$, that is, to the maximum value of the quotient of the time integral of the charging current by the capacity of the condenser. This gives us the counter electromotive force of the condenser, or the E. M. F. at the terminals of the condenser, V_1. We have then to take the resultant of this last and ON, which gives us OV_0, and this last resultant is the impressed electromotive force at the dynamo terminals.

It is necessary to bear in mind that the counter electromotive force OC at the terminals of the condenser is in quadrature with the current flowing into it, and in advance of it in phase. The diagram shows us at once that the pressu e $V_0 = O_0V$ at the terminals of the dynamo may be less than, equal to, or greater than the pressure $V_1 = OC$ at the terminals of the condenser; and that this is determined by whether the length of the line $OV_0 = \sqrt{OR^2 + V_0R^2}$ is greater or less than OC. We see that $V_0R = OC - OL = \frac{I}{Cp} - Lp^1$, and hence that OV_0 is equal to the square root of

$$\left\{R^2 + \left(\frac{1}{Cp} - Lp\right)^2\right\}I^2.$$

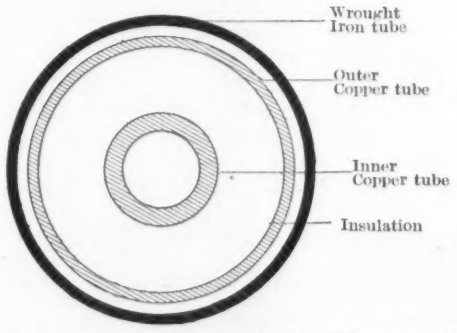


Fig. 9.—Section of Ferranti Trunk Main—Full Size.

Hence the maximum value of the charging current I is given by the value of

$$\frac{CpV_0}{\sqrt{R^2C^2p^2 + (1 - CLp^2)^2}}.$$

Also, we have the same quantity given by the relation $I = CpV_1$; hence the ratio of V_0 to V_1 is given by the value of the quantity $\sqrt{(1 - CLp^2)^2 + C^2R^2p^2}$, as we have already seen analytically. The clock diagram has the advantage that it shows us at once the various lags, and gives explicitly to the eye a proof that a gradual increase in the value of the inductance L from zero upward is accompanied by a progressive decrease in the value of the terminal pressure V_0 at the dynamo, as compared with the terminal pressure V_1 at the condenser.

14. In the next place, I wish to place before you an analysis of some experiments which have been made on great lengths of the Ferranti trunk mains between London and Deptford, and which illustrate these principles in a remarkable manner. We are all aware that these cables are concentric cables, and that they possess, accordingly, very measurable electrostatic capacity. The following are the data of the dimensions of these cables, kindly given to me by Mr. Ferranti. The inner conductor, or inner member, is a copper tube (see Fig. 9) of which the inside diameter of cross-section will be called D_1 and radius R_1, and the outside diameter D_2 and radius R_2. The outer conductor, or member, is a copper tube of which the inside diameter will be called D_3 and radius R_3, and its outside diameter D_4 and radius R_4. The insulation between the inner and outer members is compressed brown paper and black wax. The values of the diameters and radii of cross-section of these tubes are as follows (see Fig. 7):

$D_1 = \frac{9}{16}$ of an inch $= .5625$ in.
$D_2 = \frac{13}{16}$ " " $= .8125$ "
$D_3 = 1\frac{27}{32}$ " " $= 1.8437$ "
$D_4 = 1\frac{15}{16}$ " " $= 1.9375$ "

Hence we have:

$R_1 = .281$ in. $\quad R_1^2 = .0789$
$R_2 = .406$ " $\quad R_2^2 = .1648$
$R_3 = .922$ " $\quad R_3^2 = .8500$
$R_4 = .969$ " $\quad R_4^2 = .9389$
$R_2^2 - R_1^2 = .0850$ " $\quad R_4^2 - R_3^2 = .0889$

Area of cross-section of inner member $= \pi(R_2^2 - R_1^2) = .2689$ sq. in. $= \frac{1}{4}$ sq. in., nearly.

Area of cross-section of outer member $= \pi(R_4^2 - R_3^2) = .2793$ sq. in. $= \frac{1}{4}$ sq. in., nearly.

Also, we have

$$\frac{R_3}{R_2} = 2.270, \quad \frac{R_2}{R_1} = 1.444, \quad \frac{R_4}{R_3} = 1.051,$$

$$\frac{R_1^2}{R_2^2 - R_1^2} = .9185, \quad \frac{R_4^2}{R_4^2 - R_3^2} = 10.561,$$

$$\frac{2R_1^4}{(R_2^2 - R_1^2)^2} = 1.6872, \quad \frac{2R_4^4}{(R_4^2 - R_3^2)^2} = 223.068.$$

$$\log_e \frac{R_3}{R_2} = \log_{10} 2.27 \times 2.3026 = 2.3026 \times .35603.$$

These quantities are required in the calculation of the inductance of the cable.

If the specific inductive capacity of the dielectric were a definitely known quantity, it would be, of course, easy to calculate from the above figures the capacity of one mile run of the cable by the formula,

$$\text{Capacity in electrostatic units} = \frac{Kl}{2\log_e \frac{R_3}{R_2}},$$

K being the specific inductive capacity, and l the length; and to reduce this to farads by multiplication by $\frac{1}{9 \times 10^{11}}$.

In default of information to enable this to be done, the electrostatic capacity of one length was measured directly by comparison with a standard half a microfarad.

(To be continued.)

Foucault Currents in Dynamos.*

BY J. SWINBURNE

The question of the loss in dynamos by Foucault currents in the armature cores and windings has been brought prominently forward lately. Mr. Kapp and Mr. Housman published accounts of a method of estimating the losses in a recent number of the *Electrician*. Moreover, Mr. Kapp explained the method at the Institution of Civil Engineers, and the importance of the subject warrants its being brought forward so prominently. The method of estimating the loss by Foucault currents described by Messrs. Kapp and Housman consists of running the machine as a motor with no load at two or several speeds. The losses are due to friction in the bearings, air friction, hysteresis, and Foucault currents in the core and armature bars. The first three are assumed to vary as the speed, and the Foucault currents as the square of the speed. This method is, however, due to Mr. Mordey, who worked the subject out very fully in his paper on "Alternate Current Working" in 1889. He did not, however, supply the power electrically to the dynamo, but used a transmission dynamometer, though the method of testing dynamos by running them light as motors was well known. Supplying the power electrically admits of its being measured with greater accuracy, but does not allow the Foucault currents in the core to be determined before the armature is wound.

* From *Industries*.

The method has, however, one very serious objection, viz., that the loss by Foucault currents at full load is very much greater than at no load, at least in a large machine, and this makes the method inaccurate. The loss by Foucault currents in the discs is increased considerably by the distortion of the field due to the armature current, and the losses by Foucault currents in the conductors are increased greatly by the same cause. The method may thus underestimate the losses very considerably, that is to say, the losses may be double those determined in such a way. This is discussed in my paper on "Armature Reactions" in 1890, so I need not go into it farther here.

I tried a number of experiments on the stray power in 1886. Various dynamos were run as loadless motors, but the results were all vitiated by variations of the friction. The machines were, however, comparatively small, and the friction may have been large in proportion to the hysteresis and Foucault currents. I do not mean to imply that I forestalled Mr. Mordey in 1886; I was merely attempting to separate the electrical and mechanical losses. The assumption that the loss by friction varies as the speed is gratuitous, and Messrs. Kapp and Housman are really trying to determine three unknown quantities from two equations. Mr. Mordey can, however, find the friction losses at various loads and can thus apportion the no-load losses accurately. I tried another method of finding the loss by hysteresis and Foucault currents in the core. The armature, being put in the machine, had one wire disconnected from the commutator, so that the circuit was open. The armature was then treated as a choking coil, and the power measured when an alternating pressure was applied. There was no wattmeter available, so a current dynamometer was employed. The fixed coil was put in series with the armature, and the moving coil, which had only one turn, was put in series with a non-inductive resistance. The dynamometer thus became an accurate but wasteful wattmeter. By using more than one frequency, the Foucault current and hysteresis losses can be separated according to Mr. Mordey's equation.

Alternating currents also supply a most convenient method of testing armature insulations during the progress of manufacture. Before the last connections are made to the commutator several sections are included between the terminals of an alternating machine. The armature then acts as a transformer, transforming up, and testing its own insulation. This method was introduced at Messrs. Crompton's works about four years ago, and has, I believe, been used ever since. It may be made too severe, and any armature can be broken down by including few enough turns between the terminals of the alternating dynamo.

The loss by Foucault currents in a disc which is uniformly magnetized can be calculated if the specific resistance of the iron is known. Discs are sensibly uniformly magnetized in a transformer, and I have elsewhere* given the formula,

$$P = 2.6\, B^2\, n^2\, t^2\, 10^{-16}\, R.^{-1},$$

where P is the power wasted per c. c. of iron, B is the induction, n the frequency of revolutions per second of a two-pole dynamo, t the thickness of each disc in centimetres, and R the specific resistance of the iron in ohm centimetres. It will be noticed that the diameters, internal and external, do not appear in the equation, so that the loss per cubic inch does not depend on the size of the machine. To give a concrete example, we may take a two-pole dynamo, with a 20-inch by 20-inch armature with a 14-inch hole, and 600 revolutions per minute. If the armature reduction is 13,000, the loss by hysteresis comes out 450 watts, while, taking the specific resistance of iron at 10 microhm centimetres, the loss by Foucault currents is 370 watts if the discs are one-twentieth of an inch thick. The induction does not vary in a dynamo in the same way as in a transformer, so this is too low an estimate. It will be nearer the truth to take it at 450 watts also. In a small machine, which is run at 1,200 revolutions or so, the loss by Foucault currents may easily be four times that by hysteresis with the thickness of discs commonly employed by makers. It is here assumed that the discs are insulated from one another. There is no difficulty in separating them well enough to avoid any Foucault currents due to contacts.

Foucault currents in bars can also be calculated roughly, but only roughly. As large bars are seldom used there is no need to go into the methods of calculating. Twisted conductors get over the difficulty if the various component wires are not in good enough electrical contact to allow the Foucault currents to flow. The only way to determine these losses is to test the machines at full load by some of the modifications of Hopkinson's method. There are also serious losses by Foucault currents in Gramme machines which may not appear at no load.

*B. A. Paper on Transformer Design, 1889.

The losses by Foucault currents in the conductors are often very serious in alternating current machines. As the cross-induction is generally small in such machines, Mr. Mordey's method will give accurate results. The superposition of the main current does not increase the loss. For instance, if there were 100 watts lost in a main by a current already flowing, and a second current is superposed, which by itself would produce a loss of 100 watts, the two together would waste 400 watts, not 200 watts. In a dynamo, however, if the Foucault currents waste 100 watts in the conductors, and the armature loss by C^2R is, say, 200 watts, the total waste is 300, not 583 watts. It is, perhaps, unnecessary to give the explanation of this here.

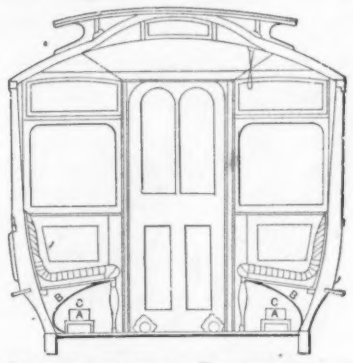


FIG. 3.—ARRANGEMENT OF BURTON CAR HEATERS.

The Burton Electric Heater.

A railroad commissioner, in discussing methods of heating railway cars, recently said that electricity was as yet too dear to enter into the question. Similar opinion was expressed by a well-known electrician some weeks ago in regard to domestic heating. If in one field the mechanical appliances necessary are not yet so perfected as to permit of its adoption, and in the other the cost of current may be too great, yet for the heating of electric cars it has been thoroughly established that electricity is not only an agent theoretically perfect, but one whose use is economically practicable.

This has been demonstrated beyond the possibility of a doubt by the application on electric roads of the Burton electric heater, the invention of Dr. W. Leigh Burton. The history of this invention, in some respects remarkable, chronicles some marked triumphs not unhampered, it is true, by the unusual suspicion in which a new departure is regarded. For some years Dr. Burton had devoted much attention to electrical science, and had carried on a long series of experiments with electric heaters. Beginning with the well-known fact that the heat generated in a conductor is proportional to the resistance of such conductor and the strength of current used, the problem was to devise some arrangement whereby the wires, when given current such as would heat them to a requisite intensity, would yet be in no danger of fusing. After much experiment it was discovered that platinum or any wire of refractory material, when of considerable length, if surrounded by finely powdered fireclay or similar substance, will, without danger of fusing, carry an electric current of such strength as would instantly destroy it if not thus surrounded. In this way the entire surface of the wire might be covered by a material which, although able to communicate the heat to the surrounding atmosphere, is of such high electrical resistance that it will not carry off a sufficiently large portion of the current to prevent its efficient action as a heat producer.

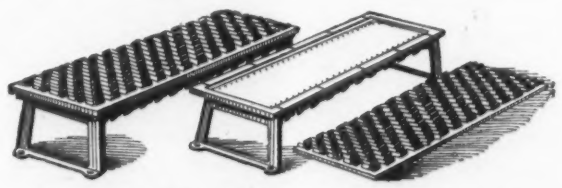


FIG. 1.—IRON CASING OF THE BURTON HEATER.

A patent was granted to Dr. Burton upon the practical application of his inventon in 1887, and some time later he secured another patent on an improved method of electrically connecting the heaters. Up to the present time, however, its use has been confined to electric cars. The apparatus used in street car work and the method of wiring will be readily understood by reference to the accompanying diagrams. Fig. 1 shows the iron casing with a corrugated covering to facilitate the radiation of the heat, which contains the German-silver wire stretched back and forth across the case and imbedded in the fireclay. In wiring the ordinary street car two such heaters are usually placed on each side under the seats, as shown in Figs. 2 and 3. The wiring is very easily done. Connection is made to the trolley wire in one corner of the car, and the current conveyed through the heaters under one seat and carried to the other side to a ground connection on the truck. The method of wiring adopted by the company is shown in Fig. 4, and for the street-car service the electrical resistance of the heaters is so adjusted that on a 450-volt circuit they use three ampères of current. When, therefore, the handle of the switch A is turned on L (shunt) from line connection and B closed, the heaters are thrown in series of two for a short time only, causing the use of six ampères of current in each set. When a sufficiently high temperature has been attained in these, which will be in 15 or 20 minutes, the handle of A is turned on G (ground connection) and B opened. This causes them to be thrown in series of four, when the heat will be maintained in them for a long time without being appreciably lowered, with the use of only three ampères of current.

The process of warming the cars is supposed to take place in the morning before the car leaves the shed, when there is no other use for the current. The normal use of the current, however, being only three ampères, the cost would be calculated on that basis. As far as regards expense it has been proved to the satisfaction of the officials on a number of roads that it is fully as economical, and even more so, when service and contingent expenses are considered, than the ordinary coal stove. Lieut. S. Dana Greene, the well-known electrician, and who is consulting electrician for the Burton company, estimates the cost to amount to less than 10 cents per day for each car, and in some cases this estimate has been found too great. The company is constantly in receipt of testimonials from various roads speaking of the heating in the highest terms as regards safety, comfort and economy. The patrons of the road using the heater are even more enthusiastic than the officials, and to any one familiar by sad experience with the dirty and gaseous condition of the average coal-heated car, the absolute cleanliness and absence of odors, together with the temperature, of a car electrically heated is a revelation in modern car heating.

The electric heater would find its warmest welcome, however, as a successor to that "deadly car stove" to whose account so many tragedies must be placed. Here the absolute safety of the electric heater should commend it, even though dividends were lessened somewhat by its use. By the employment of dynamos and storage batteries now carried on trains for incandescent lighting, the heater could be used and the increased safety and comfort would more than compensate for any expense involved.

Other uses for the heater are innumerable and suggest themselves at once. With its almost ideal qualifications, its general application is warmly urged by those familiar with its operation, and when once before the public there can be no doubt of its rapid sale.

The John Scott legacy medal has been awarded the inventor for his electric heater, on the recommendation of the Franklin Institute, of Philadelphia.

The heaters are manufactured by the Burton Electric Company, Richmond, Va., for which the Electric Merchandise Company, of Chicago, is the selling agent.

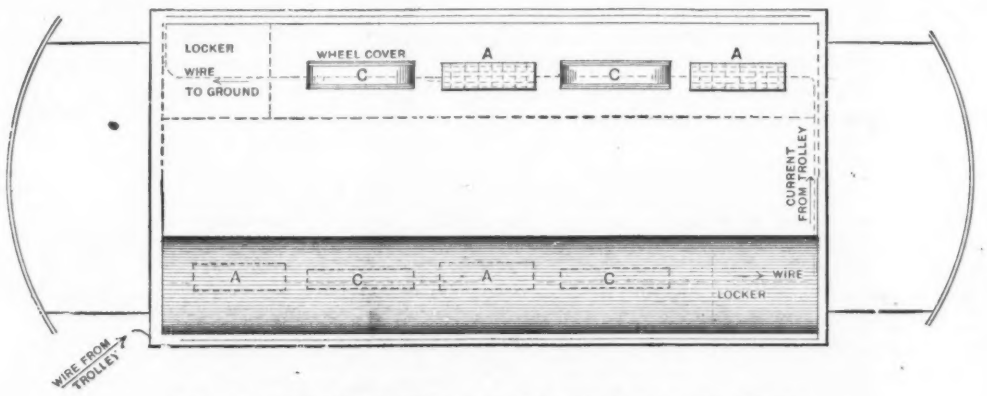


FIG. 2.—ARRANGEMENT OF BURTON CAR HEATERS.

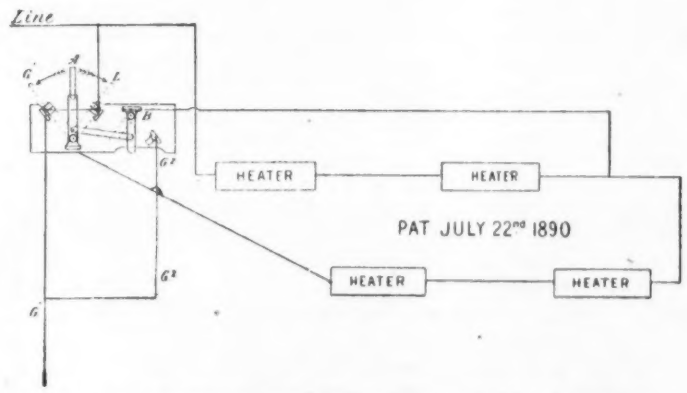


FIG. 4.—METHOD OF WIRING BURTON HEATERS.

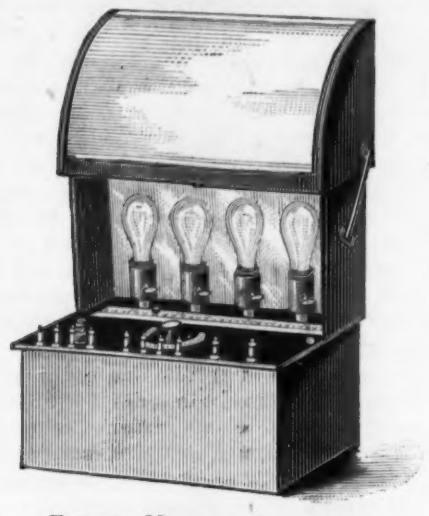
An Electro-Medical Apparatus.

The accompanying cut represents an apparatus, 15 inches long, 12 inches wide and 8 inches high, with bent glass front, intended to be used on any direct current incandescent system of 110 volts constant potential, and is adapted to replace liquid batteries used for medical purposes.

It need not be a stationary fixture or have special wires run for it, as it can be connected to the circuit in a mo-

ment by screwing the "plug" which is attached to a flexible conductor (which accompanies each apparatus) into any Edison standard key-socket in place of the lamp. It comprises also connections for attaching small incandescent lights for examinations and for headlights, storage batteries for cautery purposes, and for motor when so desired.

Any small incandescent light from one-half to six or more



Electro-Medical Apparatus.

candle power can be attached and the necessary current accurately adjusted. Storage batteries can be attached and charged to their full capacity. The apparatus is put on the market by Henry E. Stammers, of 1,424-26 Broadway, New York City.

Hill Clutch Coupling.

An improved form of Hill clutch coupling that is being placed in operation in several of the important electric railway power stations is shown on this page. The general mechanism of the Hill clutch is too well known to require explanation. The improvement, as is clearly illustrated, consists in an arrangement of the levers by which a greater amount of power is secured within a certain diameter. The ring accompanying the coupling illustrated has a diameter of 84 inches, and will transmit 4,000 h. p at 200 revolutions. Fifteen of these clutch couplings are now being built for the West End Street Railway Company in Boston, and show the same high grade of workmanship as "engine work," all holes being reamed and faced, and the two sides held together by eight two-inch steel bolts having case-hardened nuts. These are the largest clutch couplings and pulleys ever turned out, and add another proof to the increase in various lines of industry caused by the practical application of electricity to street car propulsion.

A New Electro-Plating Dynamo.

The Hanson & Van Winkle Company, of 219 Market street, Newark, N. J., has placed upon the market a dynamo, shown in the illustration on this page, in which a number of novel features are embodied. Five sizes of these machines are built. The field magnets are made of wrought iron and the cores are cylindrical in shape. The machine has a very short magnetic circuit, a matter of considerable importance.

The commutator is easily taken off, so as to renew the segments, which are made of tempered copper, and are very durable. The armature and working parts are away from the base, and are protected fully from dirt. The field magnets are wound on bobbins which are easily replaced, no return of machine and expensive repairs ever being required. Clean lubrication is one of the prominent features of the machine, requiring attention but once a week. No oil can get in the armature. Without sacrificing the electrical efficiency of the machine, it has been made one of

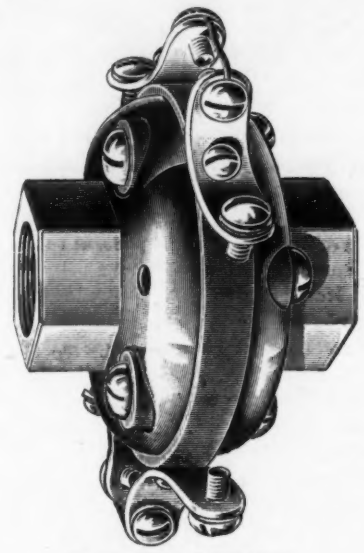
The Hanson & Van Winkle Plating Dynamo.

the most attractive in the market, and, consequently, will receive more care from those having charge of it.

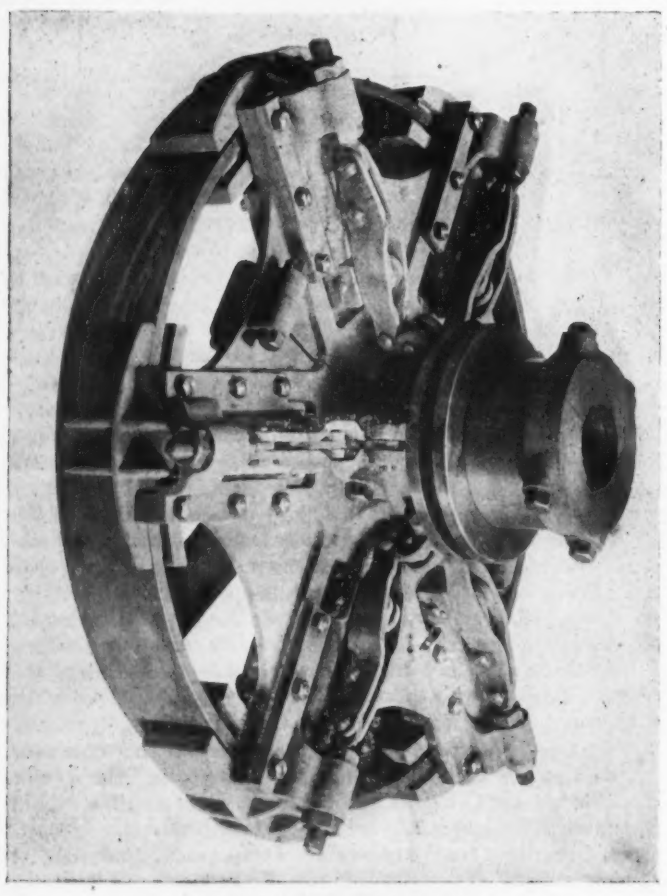
Electric Hoists in Mine Haulage.

Among the many advantages of the electric system of haulage for underground work is the ease with which the locomotive may be helped out, so to speak, where an incline occurs in the haulage way by means of stationary electric hoists operated on the same circuit with the locomotive. By their use the employment of much smaller locomotives is permitted than would be otherwise possible. For instance, for certain haulage work in a coal mine a 40 h. p. locomotive is necessary. As the entry is driven forward a fault is met in the measure, and the grade for a comparatively short distance is so increased that the locomotive, already in, will be unable to handle the work. An auxiliary stationary hoist set up at the top of this hill will remedy the difficulty. For this work special apparatus is necessary, and the Thomson-Van Depoele Electric Mining Company has gotten out electric hoists particularly fitted for underground haulage plants. The illustration shows one of these as recently made for a Western coal mine. The plant originally consisted of one hoist, but its work and the results obtained by its use proved so eminently satisfactory that two other hoists were immediately ordered.

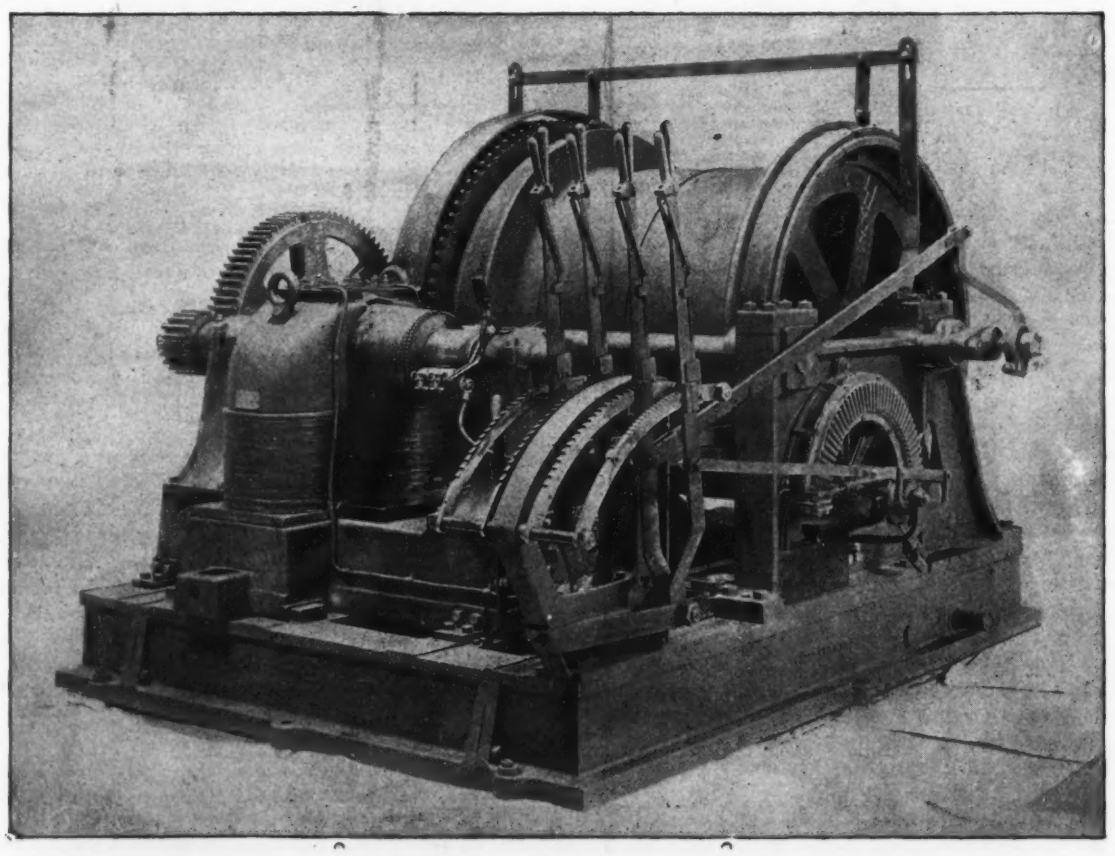
The outside dimensions of the hoist are 9 feet by 7 feet 4 inches and the total height is nearly 6 feet. The power is furnished by a Thomson-Houston motor of 85 h. p., wound for a potential of 440 volts. It is series wound and runs normally under load at a speed of 1,100 revolutions per minute. A speed reduction from the motor armature to the drum is accomplished by one intermediate shaft with proper gears and pinions, which gives a rope speed of a little over 500 feet per minute or 0.492 feet per revolution of the motor. The drum, which is mounted on a sleeve and is thrown into action with the large gear by a friction clutch, is 4 feet in diameter, with a 36-inch face. Its rotation, when running independently, is governed by two band brakes which extend around nearly the entire circumference of the drum. The outfit is equipped with five controlling levers, four of which are shown in the illustration. One operates the rheostat contact, one the drum clutch, two are brake levers, which are entirely independent one from the other, and the last throws the reversing switch, giving the drum, when thrown into action with the motor, positive motion in either direction of rotation. The controlling levers are all latched and all within easy reach of the operator. The gears and pinions are practically noiseless and carefully covered to prevent accidents, and the motor has self-oiling bearings. The Thomson-Van Depoele Electric Mining Company is getting out hoists of this general description in various sizes and for different capacities.



Insulating Coupling.



HILL CLUTCH COUPLING.



AN ELECTRIC HOIST APPLIED TO MINE HAULAGE.

Electrix Combination Cut-Out and Insulating Joint.

The accompanying illustration shows a new device, manufactured by the Star Electrix Company, of Philadelphia. It consists of an insulating joint of what seems to be a particularly strong and convenient type, to which is added a neatly arranged, double-pole cut-out device. By the use of this combination joint a separate cut-out at the fixture is dispensed with, and the whole arrangement is covered by the canopy of the fixture. Without the brass clips and fuse it can be used as the ordinary insulating joint.

The Incandescent Lamp Patent Case.

CIRCUIT COURT OF THE UNITED STATES—SOUTHERN DISTRICT OF NEW YORK. IN EQUITY.

THE EDISON ELECTRIC LIGHT COMPANY
vs.
THE UNITED STATES ELECTRIC LIGHTING COMPANY.

Before
Hon. W. J. WALLACE,
Circuit Judge.

ARGUMENT ON FINAL HEARING.

ABSTRACT OF THE ARGUMENT OF MR. RICHARD N. DYER.

This is a suit of the Edison Electric Light Company against the United States Electric Lighting Company on Letters Patent granted to Thomas A. Edison for improvement in electric lamps, January 27, 1880, which the complaint contends covers the modern incandescent electric lamp, with which we have of late years become familiar as a means for household lighting. Before attempting an explanation of the principles underlying the construction and operation of the incandescent lamp, it would seem desirable to read the patent in suit, so that the court will have before it that to which it can apply the facts and arguments as they will appear.

The patent reads as follows:

To all whom it may concern:

Be it known that I, Thomas Alva Edison, of Menlo Park, in the State of New Jersey, United States of America, have invented an improvement in electric lamps, and in the method of manufacturing the same (Case No. 186), of which the following is a specification:

The object of this invention is to produce electric lamps giving light by incandescence, which lamps shall have high resistance, so as to allow of the practical subdivision of the electric light.

The invention consists in a light-giving body of carbon wire or sheets, coiled or arranged in such a manner as to offer great resistance to the passage of the electric current, and at the same time present but a slight surface from which radiation can take place.

The invention further consists in placing such burner of great resistance in a nearly perfect vacuum, to prevent oxidation and injury to the conductor by the atmosphere. The current is conducted into the vacuum-bulb through platina wires sealed into the glass.

The invention further consists in the method of manufacturing carbon conductors of high resistance, so as to be suitable for giving light by incandescence, and in the manner of securing perfect contact between the metallic conductors or leading-wires and the carbon conductor.

Heretofore light by incandescence has been obtained from rods of carbon of one to four ohms resistance, placed in closed vessels, in which the atmospheric air has been replaced by gases that do not combine chemically with the carbon. The vessel holding the burner has been composed of glass cemented to a metallic base. The connection between the leading-wires and the carbon has been obtained by clamping the carbon to the metal. The leading-wires have always been large, so that their resistance shall be many times less than the burner, and, in general, the attempts of previous persons have been to reduce the resistance of the carbon rod. The disadvantages of following this practice are, that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions; that, owing to the low resistance of the lamp, the leading-wires must be of large dimensions and good conductors, and a glass globe cannot be kept tight at the place where the wires pass in and are cemented; hence the carbon is consumed because there must be almost a perfect vacuum to render the carbon stable, especially when such carbon is small in mass and high in electrical resistance.

The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by "air-washing," or the attrition produced by the rapid passage of the air over the slightly-coherent, highly-heated surface of the carbon. I have reversed this practice. I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere offers from one hundred to five hundred ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonized, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled, as much as two thousand ohms resistance may be obtained without presenting a radiating surface greater than three-sixteenths of an inch; that if such fibrous material be rubbed with a plastic compound of lamp-black and tar, its resistance may be made high or low, according to the amount of lamp-black placed upon it; that carbon filaments may be made by a combination of tar and lamp-black, the latter being previously ignited in a closed crucible for several hours and afterward moistened and kneaded until it assumes the consistency of thick putty. Small pieces of this material may be rolled out in the form of wire as small as seven one-thousandths of an inch in diameter and over a foot in length, and the same may be coated with a non-conducting, non-carbonizing substance and wound on a bobbin, or as a spiral, and the tar carbonized in a closed chamber by subjecting it to high heat, the spiral after carbonization retaining its form.

All these forms are fragile and cannot be clamped to the leading wires with sufficient force to insure good contact and prevent heating. I have discovered that if platinum wires are used and the plastic lamp-black and tar material be molded around it in the act of carbonization there is an intimate union by combination and by pressure between the carbon and platina, and nearly perfect contact is obtained without the necessity of clamps; hence the burner and the leading-wires are connected to the carbon ready to be placed in the vacuum-bulb.

When fibrous material is used the plastic lamp-black and tar are used to secure it to the platina before carbonizing.

By using the carbon wire of such high resistance I am enabled to use fine platinum wires for leading-wires, as they will have a small resistance compared to the burner, and hence will not heat and crack the sealed vacuum-bulb. Platina can only be used, as its expansion is nearly the same as that of glass.

By using a considerable length of carbon wire and coiling it the exterior, which is only a small portion of its entire surface, will form the principal radiating surface; hence I am able to raise the specific heat of the whole of the carbon, and thus prevent the rapid reception and disappearance of the light, which on a plain wire is prejudicial, as it shows the least unsteadiness of the current by the flickering of the light; but if the current is steady the defect does not show.

I have carbonized and used cotton and linen thread, wood splints, papers coiled in various ways, also lamp-black, plumbago, and carbon in various forms, mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters. Each wire, however, is to be uniform in size throughout.

If the carbon thread is liable to be distorted during carbonization it is to be coiled between a helix of copper wire. The ends of the carbon or filament are secured to the platina leading wires by plastic carbonizable material, and the whole placed in the carbonizing chamber. The copper, which has served to prevent distortion of the carbon thread, is afterward eaten away by nitric acid, and the spiral soaked in water, and then dried and placed on the glass holder, and a glass bulb blown over the whole, with a leading tube for exhaustion by a mercury pump. This tube, when a high vacuum has been reached, is hermetically sealed.

With substances which are not greatly distorted in carbonizing, they may be coated with a non conducting, non-carbonizable substance, which allows one coil or turn of the carbon to rest upon and be supported by the other.

I claim as my invention—

1. An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires, as set forth.

2. The combination of carbon filaments with a receiver made entirely of glass and conductors passing through the glass, and from which receiver the air is exhausted, for the purposes set forth.

3. A carbon filament or strip coiled and connected to electric conductors so that only a portion of the surface of such carbon conductors shall be exposed for radiating light, as set forth.

4. The method herein described of securing the platina contact wires to the carbon filament and carbonizing of the whole in a closed chamber, substantially as set forth.

Signed by me this 1st day of November, A. D. 1879.

THOMAS A. EDISON.

Witnesses:
S. L. GRIFFIN,
JOHN F. RANDOLPH.

In this case, your Honor, proof of an infringement of claims 1 and 2 has only been made. Claims 3 and 4, claim 3 being for the coiling of the carbon filament and claim 4 for the particular method of securing the platina wires to the carbon, are not used by the defendant, at least not in the lamps on which this suit is based.

Having placed before your Honor the patent in suit and before describing the course of Edison's work upon the incandescent lamp, I propose to attempt to explain to your Honor some of the electric principles underlying this art, with a brief reference to the distinguishing differences between arc and incandescent lamps, which will be often referred to throughout the record.

I have a chart, simply an enlargement of one of the charts in the brief, and illustrating the principle of the incandescent lamp and of the arc lamp. The figure to the left represents the incandescent burner separated from the parts of the lamp. The light is produced by the passage of the electric current continuously through a conducting strip always made of carbon at the present time. In passing through this strip it encounters a resistance to its flow, which produces heat, and the heat in turn produces light, the carbon burner being raised to that degree of heat at which it becomes luminous: and a lamp of this kind, in connection with a dynamo, forms a continuous or unbroken circuit, the current passing continuously from the source of current to the lamp and through the lamp and back again to the source, without encountering any break in the circuit, and encountering in the circuit only the higher resistance offered by the burner of the lamp, as distinguished from the conductors leading to it; and by reason of that higher resistance the burner becomes heated throughout its length.

In the arc lamp, on the contrary, we have a break in the circuit. Two carbon conductors have their ends brought close together so that an air space exists between them. The current passing across that air space disrupts and vaporizes the ends of the carbon conductors, and produces heat in those ends, and also in the carbon vapor between the ends.

That action is known as the electric arc, and was discovered, as we believe, by Sir Humphrey Davy in the beginning of the century.

The light, then, is produced by the heated ends of the conductors and a heated vapor and particles passing through that space. The resistance which is the cause of the light is located in the space in a break in the circuit and not in the conductors themselves. Any resistance in the conductors themselves would be detrimental, because theoretically, all is required to produce light at the break of the arc. Whatever resistance there is in the rods themselves is the cause of a loss of heat, of a loss of energy, by reason of the generation of heat in those rods.

So that your Honor will perceive that one of the distinguishing differences between the arc and the incandescent lamp is the location of the resistance, the resistance in the incandescent lamp being in the body of the conductor itself, and in the arc lamp being in an air space between the approaching ends of two carbon electrodes. In the incandescent lamp the light is not due at all to combustion. The carbon is surrounded by a globe in which a vacuum is produced, and that prevents a combustion, the oxygen of the air not being present; so that the light is entirely the result of the heating of the conductor, due to the obstruction which the electric current meets in passing through it.

On the other hand, in the arc lamp, the carbons being exposed to the air, are to a large extent consumed by the oxygen of the air; that is, combustion takes place at that point.

This brings us to a consideration of what is resistance. It is a short term to express the varying capacities of different substances to conduct the electric current, or the varying obstruction which different substances oppose to the flow of the electric current. Some substances have so little capacity to conduct the electric current, such as wood and the like, that they are known as insulators, and are used to shut the current in. We shall speak only of conductors, such as metal and carbon.

Whenever an electric current flows through a conducting medium, some resistance is offered to its passage. The current in forcing its way through the medium develops heat in the medium. Considered as a question of the conservation of energy, all the energy which is developed by the current in passing through a conductor, that is in overcoming the obstruction which the conductor offers by reason of its resistance, appears in heat in that conductor.

To cause a larger flow of current through a conductor of the same resistance, the pressure or electromotive force of the current had to be increased. The pressure or electromotive force is usually expressed by the abbreviation E. M. F.

A standard has been established for the measurement of the resistance of electric conductors, and the unit of measurement is called an ohm. Your Honor has seen that in the patent itself, where the old lamps are said to be from one to four ohms resistance, and where it is stated that Edison has discovered that a cotton thread may be placed in a vacuum chamber, and will have a hundred ohms resistance, and that in another form it will have two thousand ohms resistance. The ohm is the unit of resistance.

In passing I would call your Honor's attention to two more terms. The unit of electromotive force is known as the volt. The unit of resistance is known as the ohm. The unit of current flow, that is a unit expressing the amount of current which flows through a wire, is known as the ampère; and the relation between those units is this: If we have a volt in pressure, which is about the pressure exerted by a single cell of Daniell battery, and we apply that to a wire which is one ohm in resistance, a current of one ampère will flow through that wire.

Now if the wire is twice as long, or one-half the cross-sectional area, and hence has two ohms resistance, a pressure of one volt will only cause one-half an ampère to flow through. So the current is diminished by an increase in resistance, it is increased by a decrease in resistance, and the current is increased by an increase in the pressure or decreased by a decrease in the pressure.

Another element entering into the resistance of a conductor is the specific character of the conductor itself. That is known as specific resistance. Different materials have different capacities for permitting the flow of an electric current.

The energy which is developed by an electric current flowing through a conductor is developed in that conductor in the form of heat. If this is a conductor of one ohm resistance, and we pass a definite amount of electric current through it, say one ampère, we will have generated in that conductor a certain quantity of heat, which will be the result of that one ampère flowing over that obstruction of one ohm, and that will be a definite quantity of heat, and since we have the same resistance in these bodies, although one has twice the surface of the other, we will have generated in each body, by passing a definite current through it, the same amount of heat.

But, your Honor, the second fact is, that while the quantity of heat developed in each conductor is independent of the surface, the degree of heat, or the temperature to which the conductor will be raised by that amount of heat, is directly dependent upon the surface.

In the first place, it is a well known fact that at the same temperature bodies will radiate heat more or less according to the extent of the surface. The body of larger surface will radiate more heat than the body of smaller surface.

In the second place, it is also well understood that a body at higher temperature will radiate the heat faster than a body at lower temperature.

What, then, is the effect of generating the same amount of heat in two bodies of different surface? In each body the heat will accumulate as it is generated, until the temperature of that body is raised to that point where the radiation and generation of heat will be balanced. Then there will be no further rise in temperature.

Now in the body of larger surface that point of temperature or balance will be reached at a certain low temperature. In the body of smaller surface the heat will continue to accumulate until the temperature of that body is raised to such a higher degree than the body of larger surface that, by reason of its greater temperature, it will radiate the heat as fast as generated. Hence, the body of larger surface will have a lower temperature than the body of smaller surface, and that temperature is inversely proportional to the extent of the surface.

If this body has twice the surface of the smaller body, it will have only one-half the temperature, although the same energy is developed in it. We put the same work from the steam engine into the body of larger surface, but we get a temperature, a degree of heat, which is only one-half as great as we get by the expenditure of the same energy on the body of smaller surface.

This, your Honor, is very largely an economical question. It has always been possible to make electric light; but not until Edison's invention was it possible to do so practically and economically.

Now since it appears that the temperature or degree of heat which a body will attain is inversely proportional to the extent of its surface, let us see what effect that temperature has upon the light which the body will emit. We have in the case the statement made by Mr. Preece, a noted English electrician, who gives us the following data upon this subject: "Heat and light are identical in character though different in degree, and whenever solid matter has imparted to it motion of a very high intensity, in other words when solid matter is raised to a very high temperature, it becomes luminous. The amount of light is dependent upon the height of this temperature, and it is a very remarkable fact that all solid bodies become self-luminous at the same temperature. This was determined by Daniell to be 980 degrees, by Wedgewood 947 degrees and by Draper 977 degrees; so that we may approximately assume the temperature at which bodies begin to show a dull light to be 1,000 degrees. The intensity of light, however, increases in a greater ratio than the temperature. For instance, platinum at 2,600 degrees emits forty times more light than at 1,900 degrees. Bodies when raised to incandescence pass through all stages of the spectrum; as the temperature increases, so does the refrangibility of the rays of light. Thus, when a body is at a temperature of

250	degrees	it may be	called warm.
500	"	"	" hot.
1,000	degrees	we have the	red rays.
1,200	"	"	" orange rays.
1,300	"	"	" yellow "
1,500	"	"	" blue "
1,700	"	"	" indigo "
2,000	"	"	" violet "

'So that any body raised to a temperature above 2,000 degrees will give us all the rays of the sun."

The particular fact to which I desire to call your Honor's attention is the illustration that a platinum wire at 2,000 degrees emits forty times more light than at 1,900 degrees. A high temperature is necessary to produce light economically; and one way of securing a high temperature is by producing a small radiating surface, so that the energy which is put into the burner may raise that surface to a high and economical temperature.

A high resistance and small radiating surface make possible the use of a small electric current. That is the fact referred to by Justice Bradley in his decision in which he says that, "The great discovery in the art was that of adopting high resistance in the conductor with a small illuminating surface and a corresponding diminution in the strength of the current."

Aside from the effect upon the light produced, already explained, the quantity of the current controls the size of the conductor required to deliver the current to the lamp. That is to say, the larger the current the larger must be the conductor which is employed to carry the current to that lamp, and conversely, the smaller the current the smaller may be the conductor which can be practically used to carry the current to the lamp.

A conception of the two-fold character of electric energy is necessary to appreciate this. The energy which an electric current develops is expressed by the product of its pressure by its quantity, from which it follows that a small current flowing under a high pressure may be made to develop the same energy as a large current flowing under a low pressure. This will be the case whenever the product of the pressure and quantity is the same in both cases. It will also be at once perceived that if, in any case, both the pressure and quantity are doubled, four times the effect will be produced.

There is a unit which expresses the combined effect of the pressure and quantity of the electric current, and it is called the "watt," after the inventor of the steam engine. That is only referred to in passing. The watt is explained by Dr. Morton, who testified for the defendant in this case, as follows:

"It is entirely analogous to the mechanical unit of rate of mechanical work called a horse power. A horse power is the rate of doing work expressed by saying that a horse power represents 33,000 pounds lifted or moved against the resistance offered by gravity one foot every minute. . . . The 'watt' is equal to $\frac{1}{746}$ of a horse power. In other words, 746 'watts,' acting in an ideally perfect electric engine, would develop work at the rate of one horse power in the same; or one horse power applied to the pul-

ley of an ideally perfect dynamo would develop an electric current whose rate of work would be 746 'watts.'"

The flow of water in pipes may be referred to for illustration in this connection, as showing with sufficient accuracy the reciprocal relations of the pressure and quantity of electricity and the relation which the product of these quantities bears to the energy developed or the work done.

To develop a certain power in a water-wheel, with a pressure due to a head of one foot, we require a certain large volume of water, the energy developed by which is dependent both upon the head or pressure and upon the volume or quantity flowing—therefore upon the product of the pressure and quantity. The wheel which has to be operated by the flow of a large quantity of water under low pressure must be sufficiently large to accommodate it, and will have a comparatively slow speed; while the wheel that may be operated by a small quantity of water under high pressure may be smaller and will have a higher rate of speed.

We have in this diagram two instances of water-wheels, in one case that of a lower pressure, the head of water being ten feet, and in the other case the head of water being fifty feet.

By supplying each of these wheels with a larger quantity of water we will get from each wheel the same energy which will be developed in the wheels in the other case with a smaller quantity of water; that is to say, if the fall in this case is five times what it is in the first case, we may get the same result in work accomplished by permitting one-fifth the quantity of water to flow over the wheel at five times the pressure.

That is also true in electricity. We can produce the same result with one volt of pressure and 100 ampères of current that we can produce with 100 volts of pressure and one ampère of current. One difference is the size of the pipe which is required to carry the current in either case. The size of the pipe must be directly proportional to the volume which it has to carry.

Pressure itself requires no space in which to act. It is only when that pressure is used to move a mass that space is required in which the mass must move.

The hydraulic press is an illustration of that, and also ordinary stand-pipes for water-works, where your pressure is just as great whether the stand-pipe is five feet in diameter or fifty feet in diameter. The larger stand-pipe will supply a larger volume of water. If you want quantity of water you must have a reservoir. You may get the pressure by a stand-pipe.

It is a very old experiment to break a cask by a very small column of water, by running a pipe from a cask at a sufficient height, filling the whole system with water and then pouring by the dipperful a few more dippers of water into the upper end of the pipe. The result is that the cask is burst asunder. That is the direct effect of the pressure produced by the height of the water. The energy there is all stored in pressure, and not in quantity at all.

In incandescent lighting the size of the pipe is a matter of importance. In an incandescent electric lamp the same amount of energy or number of watts is developed, as I stated before, whether one ampère is used or 100 ampères. In one case the pressure must be 100 volts and in the other case one volt. So long as the product of the two is the same we have the same energy. But the size of the copper conductors necessary to carry the current to the lamps requiring 100 ampères will be many times that necessary to carry the current to the lamps with one ampère. I am told, your Honor, that the difference between the size of the conductors required to carry 100 ampères of current under one-volt pressure and one ampère of current under 100 volts of pressure is ten thousand times. The conductor in one case must be ten thousand times the area of the conductor in the other case. That I state only on information. I confess my inability to go to the extent of ten thousandths in my mathematics.

This reciprocal relation between the pressure and the quantity of the electric current will be better understood in connection with an explanation of what are known in this case as "series" and "multiple arc" arrangements. Your Honor will recollect that the patent in suit says that "one of the disadvantages of following this practice is that a lamp having but one to four ohms resistance cannot be worked in great numbers in multiple arc without the employment of main conductors of enormous dimensions"; and in order to understand that statement of the patent, contained on the first page near the bottom of the first column, an explanation of what is meant by a "multiple arc" and what is meant by "series," which is the system with which multiple arc is contrasted, is necessary for an understanding of the patent.

"Series" and "multiple arc" are expressions indicating the electrical arrangement or order of the lamps in circuit, the order in which they are connected together and with the source of electricity. That arrangement is an electrical arrangement and not a mechanical one, since the wires may be turned in any direction, and physically the lamps may be located anywhere with relation to each other.

The invention of Mr. Edison, consisting in making the burner of his lamp of high resistance and small radiating surface, enables him to utilize a small amount of current under the higher pressure; that is, the high resistance of the burner requires a certain high pressure to force the quantity of current through; and having that high resistance, a small current is all that is required to produce the light; that is, having that high resistance and that small surface (which must always be borne in mind), a small quantity of current is necessary. So it is by his invention, the invention described in this patent, an electric lamp has been produced which is capable of receiving energy and utilizing energy in the form of high pressure and small quantity, corresponding to the smaller water-wheels; so that with that lamp small conductors may be used and the high pressure will supply the current to the lamps themselves. We see at once, then, the additional thing that is accomplished by high resistance and small radiating surface. Aside from the capacity to give light economically, which is a question affecting the lamp itself, there is the capacity to give light with a small current under a high pressure. That capacity controls the size of the conductors; and the size of the conductor must be small for each lamp in order to enable a large number of lamps to be placed in multiple arc, in which arrangement they can be turned off and on the same as a gas jet.

The function of the high vacuum and of the entire glass construction of electric lamp chimneys, as well as a due appreciation of what was actually accomplished by this invention, can only be seen after an investigation of the prior state of the art as it existed in the fall of 1878, when Mr. Edison commenced the series of continuous experiments which resulted in the production, in October, 1879, of the lamp described in the patent in suit.

There are two landmarks in the topography of the prior art. One is the patent of King, in 1845; the next is the resuscitation of the art by Lodyguine, a Russian, in 1873. Before the patent of King there were experiments, philosophical and laboratory experiments, in incandescent electric lighting, and the arc lamp had reached a certain stage of development; that is, arc lamps, I believe, had been constructed, and the principle of producing electric light by the heating of continuous conductors was well known. Conductors both of metal and of carbon had been heated by the passage of the electric current through them, and the fact that both heat and light could be developed in that way was well understood; but no definite suggestion for applying that principle to an incandescent electric lamp is found in the record before the patent of King of 1845. The King patent described two lamps: One, of this patent, is a lamp employing a conductor of platinum for a burner. It is a strip of platinum foil held in pincers or clamps, supported in a frame, the whole frame being covered by a glass shade to protect the burner from mechanical injury. There is no vacuum and no sealing of any character. The platinum was to be heated to a point less than the fusing point; and since it is not attacked by oxygen at that temperature it may be used in a shade which is not sealed and simply used for the purpose of protecting it from mechanical injury. The patent also describes, what is more important in this case, namely, a lamp having a conductor of carbon.

We have produced for the purposes of the case a dummy model of this carbon lamp of King, simply to illustrate the character of the construction. We have here (exhibiting) a bulb in which these parts are placed, with a platinum wire sealed in at the top. Then we have a long tube, upward of 30 inches, which is necessary for the purpose of forming a Torricellian vacuum, the air pressure being able to support a column of mercury about 30 inches long. To exhaust this lamp it is inverted in that position and the mercury poured into the tube and bulb; and, by the way, it would be an almost impossible operation with a piece of apparatus of this kind until the entire apparatus is filled to the top with mercury. It is then inverted in a cup of mercury and the mercury will flow out of the bulb into that cup below until the column reaches that height where it will be sustained by the pressure of the atmosphere on the surface of the mercury in the cup. Then we will have at the top a vacuum, what is known as a Torricellian vacuum, and that will be maintained by means of this column of mercury in the tube. Through that column of mercury runs a copper wire and terminating in the cup of mercury below. One connection with the circuit is made by inserting another wire in the cup of mercury. The current passes from that wire through the mercury to this wire, up that wire to the carbon and to the other wire which is connected with the other pole of the source of electricity.

The first criticism of the King lamp, a criticism in the matter of detail, is that it is admitted by all the experts connected with this case that it is not practicable to make an operative carbon conductor in the way which is described in this patent; that is to say, it is not practicable to take gas retort carbon, which is a form of carbon found in the interior of gas retorts and may be secured in large pieces or lumps, and reduce that by means of a saw and file, so as to secure a conductor having any degree of tenuity. Carbon is an exceedingly brittle material, and when you come to handle it in that way and attempt to reduce it by means of a saw and file, it is not possible to get it into any great degree of tenuity, nor is it possible to secure it with that uniformity of cross section which is absolutely essential for the production of incandescence; because unless the incandescent effect is uniform in its cross section and in its character throughout this mass, there will be a higher resistance at one point than at another, and it will be more greatly heated at one point than at another. That will lead to a difference in the appearance of the burner, it will be red at one point and white at another; and that of course will lead to an earlier destruction of the burner itself. It is less efficient as a lamp and is less durable. It is admitted by all the experts that a carbon burner cannot be made in the way set out by King.

In the second place, King's lamp, his carbon lamp, and also his platinum lamp, is a lamp of low resistance. A burner having the proportions of the burner shown in this patent would be just one of the old lamps described in the patent in suit, which would have a resistance of from one to four ohms, and it would have all of the disadvantages pointed out in the patent in suit. And it appears by the patent itself that the lamp was intended for use in series, that is one after the other, and not for use in any multiple arc arrangement. Of course if it were attempted to use such a lamp in multiple arc the size of the conductor would be enormous with very few lamps; so the purpose of all these old experimenters who had these low-resistance lamps was to use their lamps in a series arrangement: and in that arrangement, as your Honor is aware, the lamps cannot be turned off and on independently like a gas jet.

With regard to the testimony of Dr. Morton and Prof. Cross in the McKeesport case, a moment only will be necessary to call your attention to the inconsistency of their attitude there and their attitude here. The Sawyer and Man patent in that case shows a lamp chamber composed of a bottom plate of glass and a globe setting down on it; and that lamp chamber was described in the patent in order to make it appear to be the same construction of lamp chamber which is now employed, and which is of an entire piece of glass—described as being wholly of glass. Dr. Morton and Prof. Cross contended in that case that Sawyer and Man had made a great contribution to the art of making lamp chambers wholly of glass, no metal about it. The interior surface was of glass and they contended that that was an important contribution to the art; but if they had believed that the King patent described the construction which they now say they believe to be described, that claim for Sawyer and Man would be impossible. Of course that special point in the King patent was not very forcibly put forward, because we did not believe then, nor do we now, that the patent means any such thing; but they make the statement in the McKeesport case after examining the King patent and all these other patents, that Sawyer and Man were the first to provide a lamp with this all-glass construction. Prof. Cross, for instance, says:

"With the exception of the prior patent to Sawyer and Man, I do not find the construction in question, or an equivalent construction, in any of the prior patents or publications put in evidence by the defendant."

Then we find that the King patent is considered very fully in the English cases, and I will read one short extract from the opinion of an English court in which the King patent is compared with the patent in suit, and that will bring the whole question in regard to the King patent before your Honor at once. The court expressed the following conclusion after examining the King patent in detail:

"Now, comparing this apparatus with the combination embodied in the second claim of Mr. Edison, we find a carbon conductor and a vacuum; but we find that the carbon was not required to be a filament—we find that it was placed in a receiver made not entirely of glass, but partly of glass and partly of the top of the mercury column, consequently that the leading wires were to pass, one through the glass and one through the mercury."

Between King, in 1845, and Lodyguine, in 1872, this record discloses only one suggestion of an incandescent lamp having a burner of carbon, and that is the patent of Roberts, which your Honor will find following the King patent. It was granted in 1852. This lamp is to be a chamber which is a globe with its lower end closed by a metallic cap and cemented to the globe. The conductors pass vertically through the cap and are connected at the upper end by a carbon conductor. The horizontal conductor is of carbon. The patentee says:

"Another part of my invention consists of a mode of obtaining electric light by passing a current of electricity through a thin piece of graphite coke or charcoal or other infusible body, being a conductor of electricity while it is inclosed in a vacuum or space not containing any oxygen or other matter which can cause the combustion or destruction of it when brought into an incandescent state by the action of the current of electricity."

I wish to call your Honor's attention to the fact that his statement is general; while he speaks of carbon, he mentions other infusible substances, evidently intending to include platinum and other things; and while he speaks of producing a vacuum he also says any other space not containing oxygen may be employed; that is, it may be a chamber filled with nitrogen, for instance. He describes the burner at another point as:

"A piece of very thin graphite about half an inch long, half an inch wide, and as thin as conveniently can be made."

That statement I have never understood from the drawing of the patent, unless the drawing intends to show an edge view of the conductor; because if the conductor is half an inch long and half an inch wide it is absolutely square, and it is made as thin as it is possible to make it.

Our criticism of this patent is, as compared of course with the Edison patent, that it describes a conductor of low resistance, and one made by reducing carbon after the carbon itself is formed, and not by reducing the material to shape and then carbonizing; that it is contained in a character of chamber in which we know that it is impossible to maintain a vacuum, and is in fact no advance at all over King, who went before him, except that it is a somewhat more convenient construction, in that he dispenses with the long tube necessary in the King lamp by reason of the character of the vacuum he employs; but he supplies in the place of the mercury tube a device, namely, a metal cap held by cement on to the glass globe, which would be very much less efficient in maintaining a vacuum, because, as we understand the matter at the present time, it is impossible to maintain such a high vacuum as is necessary for these incandescent lamps in any chamber which is made of material cemented or jointed together. It must be a glass chamber absolutely closed by the fusion of the glass at all points of the chamber; otherwise vacuum cannot be maintained. That is a lamp without such a chamber; it is provided with a carbon conductor which is not a practical conductor, being made, as King proposes to make it, by taking a piece of graphite or other form of carbon and putting it into shape; and it is a lamp of low total resistance, and we might say in addition that it is a lamp with a large radiating surface, that form of conductor which is described in the patent, namely, very thin graphite, half an inch long and half an inch wide, would give extremely large surface; for whatever resistance it has, it has a large surface; and the patent itself shows that Roberts had no appreciation of the function of radiating surface, and he had no appreciation of the function of resistance as either a means for giving light or as a means of saving copper in the conductors necessary to supply the current to the lamp. That is also true of King. The radiating surface and the resistance of the burner play no part in these lamps, so far as we can judge from the patent. They had not reached that point at all in the consideration of the matter where radiating surface and resistance were considered at all. It was simply a question with them of producing electric light. Edison took up the art where electric light had been produced. The effort that he made was to produce electric light practically, to make an electric light that was durable, in the first place; and in the second place, to make a lamp which could be used practically by the public without enormous expense in the cost of conductors, and that would be a simple piece of apparatus that could be handled by the public.

The English courts, in considering the Roberts patent, made a very brief comparison, which I will read to your Honor:

"Now, comparing this apparatus with the second claim of Mr. Edison, we find that it differed in that Mr. Roberts did not use carbon as his sole material, that he was content with the exclusion of the gases mechanically destructive, and was not alive to the importance of the mechanically destructive action of gases, that his receiver was not made entirely of glass, and that the leading wires did not pass through the glass, but through the metallic cap of the receiver."

The statement made by the English court that Roberts was not alive to the importance of the mechanically destructive action of gases is one which might be explained to advantage. The patent in suit, as your Honor will recollect, speaks of these old lamps with the use of a gas in the receiver at the atmospheric pressure.

"The use of a gas in the receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by 'air-washing,' or the attrition produced by the rapid passage of the air over the slightly coherent, highly heated surface of the carbon. I have reversed this practice."

Edison was the first to announce that gas in the lamp chamber, gas which would not support combustion, had a destructive effect upon carbon, and the English court calls attention to that,—that Roberts by stating that he might have a vacuum, or he might have a space which did not contain oxygen—meaning by that that it might contain

nitrogen or some other gas not supporting combustion,—that Roberts was not alive to the importance of the mechanically destructive action of gases. That lack of appreciation appears throughout the entire art, and it was not discovered that those gases had any deleterious effect upon carbon until Mr. Edison made the discovery set out in the patent in suit and reversed the practice in that respect.

While the incandescent light was still in its experimental stage many suggestions for subdivided or small lights produced by electricity were made. These, of course, when the light was made a success, fell into disuse, or rather were not afterward experimented upon. Among them is what is known as the Geissler tube. That is a piece of apparatus composed of a glass tube with a small piece of platinum sealed into each end, and that tube is exhausted to a certain degree, and may be filled with a particular kind of gas or may not. The platinum wires are not connected together through the tube except by the gases which fill the tube. The two platinum wires being connected to a source of high tension electricity, as to a frictional machine or an inductional coil, electric sparks, so to speak, passing through this tube cause a sort of illumination. At a time when there was no small practical electrical light these tubes were proposed for that purpose. They were proposed to be used for surgical operations, to light the cavities of the body; also for lighting clock dials. At one time they were proposed for the lighting of mines, but we have it upon the literature that the light produced by these Geissler tubes was so feeble that it was not possible to use it practically for any of these purposes.

In this connection the defendants have also referred to Crookes' radiometer, which is a device which we are acquainted with as a philosophical instrument. It is a piece of apparatus containing in an all-glass tube a high vacuum and a little mill mounted on a vertical axis, very delicately mounted, the vanes of this mill being black on one side and light and shiny on the other. If we bring a source of radiation in the vicinity of this device, the effect of the radiation on the mill is to cause it to turn, the radiations having one effect upon the black surface and an opposite effect on the white surface of the mill (exhibiting). In the making of these radiometers, the constructor, Crookes, in order to determine certain questions with regard to the character of the radiations and whether they would be equally effective if they proceeded from a source inside of the chamber, introduced a platinum wire into that chamber which was sealed into the glass, and, taking a half turn beneath the vanes, came out again; and an electric current was passed through that platinum wire so as to produce a source of radiation within the chamber. Of course there was no idea of making an electric lamp, no idea of a resisting or radiating surface or anything of that kind.

Turning to one of the books in evidence in this case, namely, "Fontaine on Electric Lighting," a book written by a Frenchman, Fontaine, in 1877, we find this statement:

"Lighting by incandescence, and the principle of its production, had for a long time fallen into oblivion, when in 1873 a Russian physicist, M. Lodyguine, resuscitated both, and invented a new lamp, which has since been perfected by Messrs. Konn and Bouliguine."

In 1874 the St. Petersburgh Academy of Sciences awarded a high prize to M. Lodyguine for his invention, and a report was presented on that occasion by Dr. Werdermann. The defendants did not put in evidence in this case the report or any description of the lamp, but we have in Fontaine's book and elsewhere a description of the Lodyguine lamp produced by Konn, and we have also Dr. Wild's report, which, it is said, includes several capital errors.

The lamp which is in evidence in this case as the improved Lodyguine lamp is the lamp of Konn which is described fully in Fontaine's book with illustrations, and is the final result of the Russian Lodyguine and his associates, it being a lamp which was constructed in Paris by expert instrument makers, and was there made in greater or smaller numbers. The exact number that were made we cannot tell. Sufficient were made, however, to determine that it was an impracticable lamp, and to further determine that it was impossible to practically produce light by incandescence.

The experiments upon the Lodyguine lamp led, as I have before stated, to the Konn lamp, which, as your Honor will see, is a glass globe mounted on a metal base, with an accurate joint. Two rods of metal rise from the base and in the frame at the top a number of carbon burners are placed. These carbon burners are arranged in connection with a shutter, a pivoted plate at the top, so that that pivoted plate brings them into circuit successively. Each carbon burner has an upwardly projecting pin, and there are several of them, and the pin of one burner projects a little higher than the pin of the next burner. The shutter falling down drops on the highest pin. That brings that particular burner into circuit. As the carbon in circuit breaks and falls out of the frame, its pin will fall from under the pivoted plate, and the shutter drop down on the next pin; and in that way Lodyguine or Konn was enabled to use a number of carbons in each lamp and bring them successively into circuit. That was to overcome the difficulty of shortness in the life of each carbon. It was an operation more or less expensive and difficult to take the lamp apart and recharge it and refit it, and it was intended to obviate the necessity of doing that by putting a number of carbon burners into each lamp, and bringing them successively in circuit, so that the life of one would be the life of all. That is at once a recognition of the defect existing in the carbon lamp as it stood at that time.

We have as the next essay in this direction the lamp of Bouliguine. He, instead of putting his carbons into the lamp which would be brought into circuit successively, put a long carbon rod in holders so that only a short section of that carbon rod was in circuit at any one time. That is to say, the several burners, instead of being in separate rods, were all in one continuous rod, and a short section was brought into circuit and made to give light, and when that was broken, by the mechanism of the lamp the rod was shoved up and a new section brought into place. So that Bouliguine accomplished in his lamp precisely what Konn had accomplished in the shutter lamp, namely, a way to overcome to a certain extent the defects resulting from the shortness of the life of the burners of the existing electric lamps.

We have, in addition to these lamps of Konn and Bouliguine, another lamp suggested by Fontaine himself in his book, but it does not appear that the lamp was ever brought to a point where it could even be tried, because he simply suggests that he is making that lamp and in no subsequent book does he give any description of the result obtained by its operation.

This period, the period during which the lamps of Konn and Lodyguine and Bouliguine and others were produced, was a period of active experimentation, having its centre at Paris. To this point the work of Lodyguine and his associates was transferred. The manufacture of carbon for arc lighting and for the Jablochkoff candle was being carried on there, and these same manufacturers, Carré, Gaudoin and others, produced their carbon rods in small sizes suitable for these incandescent lamps and for the semi-incandescent lamps of Raynier and Werdermann, which were being actively exploited at the same time, and which were a species of arc lamps consisting of a pointed carbon rod projecting against a block of carbon, the light being produced by an arc at that imperfect contact. They gave no promise of success, and were afterward given up. The Jablochkoff candle was at that time being employed to some extent for lighting the streets of Paris, and it seemed that everything was ripe for the introduction of a small or divided electric light for interior illumination provided a suitable lamp could be had. This led to an investigation of these lamps by Fontaine, the writer of the book on electric lighting to which I have before referred. It is only by understanding the defects of these prior lamps that we can fully appreciate the advantages of the lamp covered by the patent in suit.

In order to determine the actual value of the system of lighting by incandescence, Fontaine made a series of experiments with several Konn lamps, of which he gives us an account in his book on electric lighting, the original edition of which was published in Paris in 1877. He says:

"When the receivers are sealed and the contacts carefully put in line, the carbons last for a satisfactory period. The first carbon of a lamp never lasts for less than a quarter of an hour, sometimes it breaks at the end of thirty to thirty-five minutes, but that is very rarely; its average duration is twenty-one minutes. The succeeding carbons last upon an average for two hours, so long as the luminous intensity does not reach forty burners, in which case the average duration is only half an hour."

He refers to carcel burners. One carcel burner is equal to nine and one-half standard candles. Now we reach the important point of this statement:

"The vacuum never being perfect in the receivers, the first carbon is in greater part consumed."

That is to say, there is combustion there of the first carbon on account of the oxygen that remains in the lamp chamber.

"It would appear that consequently upon the little oxygen contained in the lamp being transformed into carbonic acid and carbonic oxide, the carbon should be preserved indefinitely. But there is then produced a kind of evaporation which continues to slowly destroy the incandescent rods. This evaporation is, besides, clearly proven by the perverulent deposit of sublimed carbon that we have found on the interior surface of the bells, on the several interior parts, rods, contacts, hammers, etc."

Here, then, your Honor, was a defect of vital importance, notwithstanding the fact that the carbons were removed from the effects of oxygen and were not consumed, as Fontaine says, yet they were volatilized by the action of the electric current. The carbons were without stability, even when surrounded by an atmosphere which would not support combustion. That is the first explanation we find in the literature of the art of why the carbons of these old lamps had such a short life; of why it was necessary to make these old lamps separable and make them mere lanterns in which the wicks could be renewed after their brief existence. Fontaine made exact experiments and found that even without oxygen present, and when it would be supposed that carbon would last indefinitely, because there could be no combustion, yet there was a volatilization of the carbon which slowly dissipated it and made the life of the burner exceedingly brief.

From these experiments by Fontaine, and similar results obtained by others, the conclusion was reached and generally accepted by experimenters upon incandescent electric lamps that there existed this insuperable obstacle to success with carbon as the material for the burner; and the opinion was quite generally entertained that success was more likely to be reached with metals.

The whole question came down to the statement made by Judge Bradley in the McKeesport case, in his criticism of what Sawyer and Man were attempting to do. He says:

"They may have made a lamp that would burn; but was it a success or was it a failure? Did it ever go into use? What was the object of all the experiments made by them and others? Was it not to make an electric lamp that could be successfully used by the public and have a commercial value?"

That is the whole question, a lamp which could be successfully used by the public and have a commercial value; and that lamp must be a small lamp, which will take the place of a gas light and which will be capable of being put into the hands of the public and handled as a gas jet is handled.

The first experimental data to determine whether the incandescent lamp was capable of this treatment was furnished by Fontaine, who connected the Konn lamps both in series and in multiple arc with the battery with which he experimented. The results are given in detail in his book, which is in the record. It appears from them that the total light produced was rapidly diminished by adding lamps to the circuit. Of course it must be possible to add lamps to a circuit and take lamps off a circuit, and yet have each lamp give its proper amount of light. When we turn the lamp on it must give the light for which it is designed; and if the light rapidly diminishes as we turn our lamps on of course the whole arrangement is impracticable. That is what Fontaine found, that the total light produced was rapidly diminished by adding lamps to the circuit. He evidently hoped that if one lamp, connected alone with the battery, gave, for instance, a light of 50 carcel burners, two lamps connected with the same battery would give approximately 25 burners each, or 50 burners total, and that five lamps so connected would give approximately 10 burners each, thus preserving the same total. But he found that the addition of a very few lamps to the circuit, whether arranged in series or in multiple arc, was accomplished by an enormous loss of light. In fact, when the battery was so arranged that a single lamp in the circuit gave a light of from 40 to 65 burners, the addition of four lamps resulted in the production of practically no light from any of the lamps. From this demonstration he concludes that the subdivision of electric light by means of incandescent lamps was an impossibility.

The fallacy underlying these last experiments of Fontaine was that he assumed that the smaller lights should be produced by passing a smaller current through the same lamp; that is to say, the temperature of the carbon burner which gave fifty carcel burners, or about 475 candles of light, was to be reduced until it gave the moderate light of a gas jet, or 16 candles. Fontaine was absolutely unaware of the effect of resistance and radiating surface upon the amount of light which the lamp would give, and of course when he came to pass his smaller current through the same lamp he produced a smaller amount of heat in that burner without reducing its radiating surface. Why? The burner had a lower temperature, and as its temperature decreased the light decreased in an enormously greater ratio. As we saw before in connection with the explanation of radiating surface, the reduction in the temperature of a burner is accompanied by a reduction in the light which is equal to the cube of the reduction of the temperature. If we reduce the temperature one-half we reduce the light to one-eighth. So Fontaine, when he attempted to produce his smaller lights by producing less heat in each burner, immediately fell upon the difficulty that the reduction of heat being accompanied by such an enormous reduction of light, he very soon reached the point where he had no light at all. If he had known that lamps could be constructed of a high resistance and small surface, if he had thought of that, he would have come to a different conclusion in regard to the possibility of subdividing the electric light.

I explained that two bars to the progress of the art had been raised by the demonstrations of one Fontaine. The first was, that carbon was subject to volatilization under conditions under which it could be used, and hence that no successful incandescent lamp could be made with a burner of carbon. We also showed, I think, that that conclusion, reached by Fontaine, was generally accepted by the art.

The second bar raised by Fontaine was that, even if such lamps could be made durable, the electric light could not be subdivided by means of them. When they were put in circuit in numbers the amount of light given out would be rapidly reduced by the addition of lamps to the circuit either in multiple arc or in series, or the incandescent lamp was relegated to the same field as the arc lamp, namely, for the lighting of large spaces with large surfaces.

Before stating, as I expect to somewhat briefly, the history of Mr. Edison's work, I wish to refer also briefly to the work of others contemporaneous with Mr. Edison, in order to show that nobody except Mr. Edison appreciated the conditions upon which success was to be obtained, except one person, Lane-Fox, an Englishman, who took out several patents, who appreciated those conditions, however, as expressed by one of the witnesses, only as an unattained desideratum. No practical apparatus was made by Lane-Fox. He had a proper appreciation of the general principles; that is, high resistance and small radiating surface, as a means for securing the end, but he made no suggestion for a practical way of attaining those ends; and in respect to this matter of a proper appreciation of the principles, it appears by the record, and is shown by the brief, that Mr. Edison was prior to him in that appreciation; and so far as reaching the practical lamp goes, Mr. Edison, of course, reached that first.

In 1879 we have another edition of Fontaine's book. You must recollect that Edison produced the successful lamp in October, 1879. So that with the Parliamentary investigation in the spring of 1879 and Fontaine's book later on in 1879, we approach very closely to the time when Edison made this invention.

At the time of the publication of the second edition of Fontaine in 1879, the Jablochkoff candle and arc lamp was in use to some extent, and the ordinary form of arc lamp was beginning to be employed commercially. The semi-incandescent or arc incandescent lamps of Reynier and Werdermann were at that time thought to give the highest promise for the solution of the problem of the subdivision of the electric light. Fontaine says that M. Reynier had made the best semi-incandescent lamp. The last would, without doubt, arrive at a practical solution of the problem of lighting by small electrical foci, did it not present some difficulties almost insurmountable.

The work of Sawyer and Man, which appears at length in the record, was carried on contemporaneously with that of Edison. For the present purposes we will simply say that that entire matter was investigated by Mr. Justice Bradley, with the result which your Honor has before seen, the conclusion being reached that they were pursuing the wrong principle and did not reach success.

It appears that Mr. Moses G. Farmer made some experiments upon electric lighting. He is an American electrician of considerable note. Among other things, he took out a patent in March, 1879, on an electric lamp having a burner of carbon. That lamp is shown on this chart, and consists of a globe provided with a rubber stopper at the bottom. Two metallic uprights pass through that stopper, the uprights carrying large carbon blocks at their upper ends, between which is held by spring pressure a small horizontal rod of carbon. This chamber is to be filled through the tube at the bottom with nitrogen or similar gas, which will not support combustion.

We know that such a seal as that, simply a stopper put into a globe, would not be effective to maintain the conditions of a nitrogen atmosphere. The expansion and contraction which would go forward with the lighting and extinguishing of the lamp would force the gas out and draw the air in.

A criticism of Farmer's lamp is found in Sawyer's book on electric lighting, which is in the record, and it seems to be an entirely fair one. He gives it with an illustration. He says:

"The lamp which was patented by Farmer, March 25, 1879, has not progressed beyond the stage of laboratory experiment. It is perhaps less practical than the lamps of Konn and others in these respects: that the incandescent rod or pencil is held between large blocks of carbon in such a manner as to greatly obscure the light; and that the sealing is effected by means of a rubber stopper through which pass the conducting supports, which, being good conductors of heat, must inevitably cause the lamp to unseal."

The patents of Lane-Fox, which are in the record, are four in number. They are English patents, and they were discussed with great thoroughness in the English litigation. The lamps illustrated by the drawings of these patents are, first, a lamp with a platinum conductor, and, second, a lamp with a bridge, as he calls it, of saturated asbestos, an arrangement which nobody has yet succeeded in making of any use. The lamps are shown made in two parts, evidently, with a glass globe closed at one end by a metal cap. The patents, however, contain some statements which, although indefinite, may possibly mean that he also contemplated the use of an all-glass sealed chamber, and those same patents show that he appreciated the necessity of a high resistance and also perhaps the necessity for a small radiating surface.

However, as we have said, he describes nothing that is at all practical.

The Lane-Fox patents, while dated in the fall of 1878, were granted as a matter of fact by the filing of the complete specifications in the spring of 1879, and Mr. Edison's work in the fall of 1878 and the early part of 1879, prior to the actual grant of these patents, showed that he had the same appreciation of high resistance and small radiating surface at a date earlier than any effective date which can be given to the Lane-Fox patents in this country; and, of course, not being published until after the filing of the complete specifications, Mr. Edison could not have received from those patents the knowledge he had of the necessity of high resistance and small radiating surface.

In connection with the consideration of the prior state of the art we are assisted by the arguments of our friends in the case before Mr. Justice Bradley, a few lines from which I will read, your Honor. In that case they represented the same client that they do here; that client, however, being the complainant and not the defendant, as it is in this case. In their brief they state, after referring to the general principles underlying the consideration of arc and incandescent lamps:

"These general principles have been known for at least eighty years, and for nearly forty years prior to Sawyer and Man's invention numerous experimenters and inventors had sought to utilize them in the production of light commercially by the incandescence of various materials, principally very refractory metals, such as platinum and iridium, and substances such as carbon, which are still more refractory and relatively poorer conductors.

"It was well known at least as early as 1845 that when carbon was used in this way as the illuminating conductor of an electric lamp it was necessary to protect it from the oxygen of the air by enclosing it in a sealed transparent chamber, from which oxygen was excluded, in order to prevent its combustion when heated to incandescence.

"Although, however, a vast amount of experimental work was done with incandescent lamps, and a very large number of patents were taken by different inventors for various devices connected therewith, incandescent electric lighting did not meet with any commercial success prior to the invention of Sawyer and Man."

With respect to the work of Mr. Edison upon this subject we have in the record depositions given by him and by other witnesses, which were originally taken in the interference controversy with Sawyer and Man, relating to the invention of the use of the specific material paper as the incandescent conductor of the electric lamp. The issue in that case being that specific invention, there is a great deal said in the testimony with regard to it which is not at all relevant here; but that testimony furnishes sufficient material from which we can gather an accurate idea of Mr. Edison's work upon the incandescent lamp, and in addition, in the present case the defendants subpœnaed Mr. Edison and examined him somewhat cautiously, but not without getting from him some statements about his work, and that furnishes us with additional material upon which to make a statement of the course of his work.

It appears that in 1877 Mr. Edison started his experiments upon this subject, made a few experiments, which resulted in showing him that carbon would not have any considerable life under the conditions which he could then command, and he discontinued those experiments, to renew them in the fall of 1878.

We have in the record three sketches of this early period of 1877, showing that even at that time Mr. Edison appreciated the fact that for a multiple arc arrangement of the lamps he needed a high resistance. Those are referred to in the brief.

With regard to these first experiments Mr. Edison says:

"I think my first experiments were with heating platinum wires to incandescence. Afterwards, heating carbon paper up to incandescence in the atmosphere. Also, coating the carbon with powdered glass, which, in melting, was to protect it from the atmosphere. Also with powdered silicon. Also in the lamp marked 'Edison's First Incandescent Lamp.' Afterwards by the passage of current through pieces of boron and silicon, rendering them incandescent. Also silicon and boron placed between carbon points. All these experiments, I believe, were conducted between September, 1877, and January, 1878."

He further says:

"The results of the carbon experiments, and also of the boron and silicon experiments, were not considered sufficiently satisfactory, when looked at in the commercial sense, to continue them at that time, and they were laid aside."

The first incandescent electric lamp which is referred to there—that is simply the name which was given to the exhibit by the counsel who put the exhibit into that interference case—is a piece of philosophical apparatus, common in most laboratories, consisting of a glass globe closed by metal caps, and having a sliding rod through the upper cap, the chamber being hollow and adapted to being connected with an air pump. This piece of apparatus was fitted up with clamps inside of the lamp, and in that piece of apparatus, exhausted by means of the air pump, he tried pieces of carbon and various other materials, with a result which simply served to satisfy him that they were not sufficiently satisfactory when looked at in a commercial sense to continue them at that time.

In August, 1878, he took up the work again. Experiments were made upon the use of carbon brought to incandescence by an electric current under the bell jar of an air pump, the air pump shown to the left of that figure, which he had in his laboratory, this being the complete bell jar of the pump and that the separating part. That air pump was fitted up with a frame for holding a carbon or other burner, and the bell jar being exhausted by the air pump, the electric current was passed through the burner.

Carbon pencils were also formed by rolling up tissue paper covered with tar and carbonizing the rolls, and those were used for obtaining the light upon the arc incandescent principle and an apparatus similar to that shown in the patent taken by Mr. Edison. That is the third figure there. He took those small rolls of carbon and used them on the arc incandescent principle. It has no particular relevancy to this matter. It is simply one of his experiments.

The experiments with incandescent carbons under the bell jar of an air pump were hardly more successful than those which had been performed the year before with a vacuum globe, so far as producing a continuous electric light is concerned.

As experiments they were successful, in that they proved to Mr. Edison that carbon was a material too easily oxidized and destroyed to be available under the conditions which he was able to obtain. He therefore suspended his experiments with carbon, and turned his attention to the construction of a lamp with a burner made of a material, such as platinum, which would not oxidize so readily.

Mr. Edison has given us a summary of the experiments leading up to the platinum lamp.

"We, in November or December, 1878, had our vacuum pump placed in order to conduct some experiments on incandescent carbon conductors in vacuo, and we tried a great number of experiments with paper carbons, wood carbons and carbons made with carbonized broom corn. What we desired at that date, and had concluded as the only possible solution of the subdivision of the electric light, was that the lamps must have a high resistance and small radiating surface, so as to be capable of being worked in multiple arc commercially, and our calculations showed us that the lamp must have at least 100 ohms resistance to compete successfully with gas; otherwise, if the lamps were of low resistance, the cost of the main conductors would be so great as to render the system uncommercial. What is meant here by a subdivision of the electric light is, that many thousand lamps could all be placed upon a single circuit, and be entirely independent of each other.

"We, from our previous experiments, knew that we could get the requisite resistance and small radiating surface necessary for a commercial use of the light by means of carbonized paper or wood; and, therefore, while working to accomplish this end by means of platinum, we endeavored, by a more perfect vacuum, to obtain incandescent conductors of carbon, which would give us the result.

"But our experiments in November, as before mentioned, with a good pump, wherein we used paper and wood carbons, were not so satisfactory as the experiments we were conducting with platinum conductors. When we made the carbon in such a form as to have a small mass and high resistance to suit our purposes, it would last but several minutes.

"We then laid these experiments aside, and went on with platinum, to endeavor to obtain a lamp of high resistance and small radiating surface."

This testimony was in a case in which this patent was not in issue at all, in which there was no occasion particularly to refer to what he had in mind. The thing in issue was the specific invention of carbonized paper for this purpose, yet it is impossible for him to tell the story without referring to the invention which he actually did make in this connection, the great invention. So he says that what they desired at that date was that the lamps should have a high resistance and a small radiating surface, so as to be capable of being worked in multiple arc commercially.

"And our calculations showed us that the lamp must have at least 100 ohms resistance to compete successfully with gas; otherwise, if the lamps were of low resistance, the cost of the main conductors would be so great as to render the system uncommercial."

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"*The great point we desired was a lamp of high resistance and small radiating surface, and it did not matter very much whether it was of carbon or of platinum.*"

The platinum lamps which he refers to are shown on this chart, this being the platinum lamp of 1878, and this the platinum lamp of 1879. Here is a platinum conductor in a globe, not sealed, and a rod passing centrally through it is connected with a lever. The function of that lever is to control the lamp. The platinum, in order to give light economically, must be brought very near to the melting point. That has been the great difficulty or was the great difficulty with all platinum lamps, that the platinum had to be brought so near to the melting point in order to give the light that a slight variation in the current might carry it beyond that point, and the lamp was immediately destroyed. So, in order to avoid that if possible, he put a regulator in connection with the lamp, so that when the heat reached a certain point the regulator would work and cut the current off from the lamp for the moment.

His platinum lamp early in 1879 has a platinum wire wound on to a bobbin and sealed into an all-glass globe. That is the highest perfection that a platinum lamp ever reached, probably; but he still found it desirable to use an arrangement to regulate the current supplied to that lamp. For that purpose he puts a shade or a globe over the lamp, and, forming a closed air space connected by a tube with a bellows arrangement, that bellows arrangement works the regulator.

As the heat of this lamp was increased the air in the space around the lamp in this globe was expanded, and when a certain point was reached the regulator worked and cut the current off from the lamp. So in that way, although he had finally reached a platinum lamp in which the platinum conductor was in a high vacuum and in an all-glass sealed chamber, yet, such was the difficulty with platinum that he still found it necessary to use the thermostatic regulator, and even with that, as we know, the platinum lamp was not a success. In fact, as he himself tells us in his testimony, the platinum lamp, notwithstanding the fact that the platinum lamp was in a high vacuum, was still subject to disintegration, the phenomenon which prevented all platinum lamps from being a success.

With respect to the transition from the platinum lamp to the carbon filament lamp of the patent in suit, Mr. Edison, in testifying in 1881, made the following statement:

"But when, in the course of our attempts to attain the same objects by means of incandescent platinum, we had procured a Sprengel mercury pump and ascertained that we could get exceedingly high vacuo, it occurred to me that perhaps a filament of carbon could be made to stand in the sealed glass vessels which we were using, exhausted to a high vacuum, and in October, 1879, we made lamps of paper carbon.

"And in October, 1879, we made lamps of paper carbon and carbons of common sewing thread placed in a receiver made entirely of glass, with the wires sealed therein by fusion, and the whole exhausted by a Sprengel mercury pump to nearly one-millionth of an atmosphere, and these filaments of carbon, although excessively fragile, owing to their small mass, had a smaller radiating surface and higher resistance than we had hoped; *we had reached the conditions where, notwithstanding the carbons were small in mass and filamentary, they were stable*; sufficiently so to allow the economical subdivision of the electric light and the possibilities of competing commercially with lighting by gas. *It was the new conditions which caused this lamp to be a success*, which conditions were high vacuum in a receptacle in which no deterioration or lowering of the vacuum occurred to destroy the carbon.

"These experiments resulted in the lamp and various modifications and forms, more particularly set forth in my Patent 223,898, and in the application now in interference."

Mr. Batchelor, Mr. Edison's principal assistant for many years, gives testimony at length, which is quoted in the brief. I will refer to one or two statements. Referring to the 1878 experiment Mr. Batchelor says:

"*It had early been decided by Mr. Edison that the requisite material for his incandescent lamp should have a great resistance combined with the least possible surface.*"

There we have the whole thing.

And referring again to the experiments upon the platinum lamp, Mr. Batchelor makes a very pertinent statement, showing the analysis that Mr. Edison applied to this subject. He says:

"Mr. Edison very frequently sat down at my table and worked for hours helping me on these experiments. *Our conversation frequently was directed to getting the highest resistance in the least possible space. I remember once or twice during these conversations, early in* 1879, *he remarked how easy it would be to get this resistance if carbon were only stable.*"

He knew that carbon was what he wanted, on account of its infusibility, on account of its high specific resistance, but carbon could not be used because it lacked stability; and, says Batchelor, "Mr. Edison often remarked how easy it would be to get this resistance *if carbon were only stable.*"

Mr. Upton, another assistant of Mr. Edison, also testified in this interference case relating to carbonized paper. While there was no occasion for saying anything about a thread lamp or the discovery of the stability of carbon, yet those facts were so firmly impressed in Mr. Upton's mind that he couldn't tell the story with respect to the paper lamp without telling about this discovery of the stability of carbon, and the fact that the discovery was made with a cotton-thread lamp, which had nothing to do with that particular controversy at all. He says (Vol. 5, 3,239):

"I recollect when one of the first successful loops was made. Frances Jehl and I measured the resistance, cold, of the carbon. My recollection is that it was about 140 ohms. The carbon was burned for a number of hours and again tested and no change found in its resistance. This was repeated several times, burning and testing until the lamp gave out. I remember that *we all felt very much elated* at the fact of the carbon not changing its resistance, *for it showed that there was no wasting away of the carbon.* We then felt that it was possible to make a system of electric lighting simply by adding to the life of the lamp, which we have since done."

And in the next answer he says that that experiment was with a lamp having a cotton-thread carbon.

The conditions existing in Mr. Edison's lamp and the advantages of its most important features of construction are found stated by Mr. Edison in his interference deposition of 1881. We cannot restate them better than he has himself stated them, and with your Honor's permission I will read what he says about the advantages of that lamp:

"But these lamps, in addition to the fact that they lasted for a long time, had other characteristics, without which, even with a long life, they would not have been available for competing with gas.

"These important characteristics were that they were of high resistance, of small radiating surface, and hence economical, for the reason that smaller conducting wires could be used for conveying the current, as owing to the high resistance of the lamps weak currents were only necessary, and sufficient energy to produce the result was forced through the wire and lamps by increasing the electric pressure or electromotive force. If lamps of low resistance were placed in multiple arc in a single circuit, the aggregate resistance of all the lamps would be very low, and conductors of correspondingly large dimensions would have to be used, otherwise a great loss of current in the form of heat would take place on the conductor. Hence, if the resistance of each lamp was made, say, one hundred times greater, then the conductors could have a hundred times less area, and the losses would be the same in both cases. With small radiating surface less energy is required to produce a candle power than on a larger surface."

With the old type of lamps, having rods, it became necessary to provide means for the expansion and contraction of the conductor, and also the means of protecting lamps from the heat of the burner. It is quite remarkable that from this small filament of carbon, having a temperature of probably upwards of 2,500 degrees, the slight capacity of that material to conduct heat back to the wires prevents it from delivering sufficient heat to the wires to destroy the seal. Of course, if those small platinum wires were heated by heat conducted back to the burner, they would certainly expand and crack the glass around them, and the vacuum would be destroyed. So that the small filament of carbon permits us to make the simple connection of the carbon burners with those wires and to seal the wires into the glass and to hold them there.

It appears amply by the testimony put in on behalf of the complainant that there is disintegration going on, even in modern lamps; but it does not go on sufficiently to make the lamps uncommercial, and that there was indeed a practical discovery in so reducing that disintegration and finding how that might be so reduced as to lift the lamp from a failure into a success.

And then it is further shown by the testimony that, as the art stands at present, the lamps are not destroyed by means of disintegration. What it is that brings those lamps to an end finally is not ascertained. Mr. Edison says that he has himself devoted a great deal of time and considerable expense to finding out what is the cause of the termination of the life of the lamps. He has not been able to find that out. Formerly there was no doubt as to the cause. Lamps terminated, and terminated very quickly, owing to the disintegration of the carbon. Now that dis-

integration only exists as an inconvenience in the slight blackening of the globe, and not as a factor in the final destruction of the lamp.

The defendants may argue that that is simply a matter of degree; but it seems to us that it is not a mere matter of degree, in the obnoxious sense, and that which can turn failure into success can certainly not be so characterized.

Following the cotton-thread lamp of Oct. 21, 1879, and during the same month lamps were made from carbonized paper in the form of a circle with a small section between the wires broken out; from lampblack and tar kneaded to the consistency of thick putty and rolled out; from various kinds of thread and paper, including card-board; and from various wood splints and fibres—all prior to the filing of the application for the patent in suit.

The special matters upon which the greatest preference was to be exercised were the material to be used for the filamentary burner and the form in which to put the conductor. The invention once having been made, it became then a matter of investigation to find out what was the best material for the purpose, and what was the best and most suitable form, all things considered, to give the burner.

For his first essay before the public Mr. Edison selected thin bristol board as the material and cut it into a form approximating the shape of a horseshoe and then carbonized it--being the lamp to the right (indicating). This became known as the horseshoe paper lamp. The manufacture of this special type was commenced in November, at which time a special steel mold was made to stamp the conductor with, and by December, 1879, these lamps had been made in considerable numbers. Conductors were run around Menlo Park to various lampposts and into some of the houses connected with dynamo machines at Mr. Edison's shops. Lamps were connected with these conductors, and early in December, 1879, a private exhibition was given in Mr. Edison's house, and toward the end of December a public exhibition was given, which was attended by thousands of visitors.

I propose very briefly to show the commercial development of the incandescent lamp in Mr. Edison's hands; and the facts upon which we shall argue that the invention is one of great utility, judged by the extent of its use and by his exploitation of the business.

This public exhibition was given towards the end of December, 1879, and at that time an account of this new Edison lamp was published in a full-page article in the New York *Herald* for December 21, 1879.

Mr. William E. Sawyer was at that time a representative electrician, located in New York and engaged in work upon electric lighting. He was naturally incensed that it should be said that Edison had produced a durable and commercial electric lamp where he had failed. He is the Sawyer of the Sawyer and Man experiments. He published a challenge to Mr. Edison to prove the statements made in the *Herald* article, which is found in volume 6 at page 4,168, in which, after stating that Mr. Edison had never made any very great inventions, he denies every one of the allegations made on behalf of Mr. Edison, and challenges him specifically to do certain things. The first one is to maintain a vacuum in his lamps. The second one is to run his carbonized paper lamp three hours. In practice Mr. Sawyer says it will last 20 minutes in a perfect vacuum.

The journals are full of criticisms of this character, both in this country and abroad, many of which are included as exhibits in this case, and which are referred to in the brief, and will not be read at the present time.

After these criticisms, based upon the *Herald* article, we next come to an account of Mr. Edison's light, written by one of his assistants, Mr. Upton, and published in *Scribner's Monthly* for February, 1880. We have it in the record, a fully illustrated article, which is substantially correct in its statements, although reduced to popular form. This article was the occasion for a renewed attack by the writers and critics, who said that not only would this lamp suffer from disintegration and would lack durability, but that many of the other statements made by Mr. Upton as to the requisites of commercial success were based upon false premises and could not be true. Secure in possession of a practical lamp, Mr. Edison continued the exploitation of his invention with a feeling that scientific ignorance must finally give way in the face of commercial accomplishment. The lamp was submitted to tests of scientists called in for the purpose, and we have in the record an account of a test made by Professor H. A. Rowland, of the Johns Hopkins University, and Professor Charles F. Barker, of the University of Pennsylvania, published in the *American Journal of Science* for April, 1880 (Vol. 6, 4,232). Also a test by Profs. Morton, Mayer and Thomas at the Stevens Institute of Technology (Vol. 6, 4,237). Also a test by Profs. Brackett and Young, of Princeton, on Edison's dynamo and lamp—all printed in the record—early in 1880.

These tests and the commercial introduction of the lamp into this country soon confirmed here the accuracy of the claims advanced for Mr. Edison in the *Herald* and the *Scribner's Magazine* article of Mr. Upton, that his lamp was a durable one, and that by means of it the electric light could be practically subdivided.

The European electricians, however, were not turned from skepticism until Mr. Edison exhibited his apparatus at the Paris Exposition in 1881. Infringers had already arisen and also exhibited similar lamps at that Exposition, the defendant in this case being among them.

At this exposition Mr. Edison was awarded by several juries various diplomas of honor, gold medals, etc., and these were all substituted by the congress itself by giving him a special diploma of honor—no other exhibitor of incandescent lamps receiving any such honor—and Mr. Edison being also decorated by the government with the high rank of officer of the Legion of Honor.

The report of the subcommission on incandescent lamps at the Paris Exposition appears in evidence in this volume, showing that, although there were infringers and imitators at that exposition, still the commercial value of Mr. Edison's lamp was greater than that of the others; that while he had imitators and infringers, he himself was in the van of progress, and was making the best lamp under this patent that there was upon the market, and I might add that he has continued in that position down to the present time.

In the spring of 1880, referring to the commercial use of his lamp, the steamship Columbia, of the Oregon and Transcontinental Company, was lighted with the Edison paper carbon lamps. Later, in the same year, bamboo, the material which has since been used, was adopted as the basis for the carbon filament. No other changes in this lamp have been made except refinements and a return to the carbon clamp of the patent.

The paper lamp of November, 1879, being held by little metal clamps, in the present lamp he has returned to the suggestion of his patent and secures the filament of carbon to the wires by means of a carbon paste.

We have in the record extracts from bulletins issued by the Edison company showing the commercial development of the business; and it appears from these that in June, 1882, there were 67 Edison isolated plants in operation in this country, aggregating 10,424 lamps; in October, 1882, 123 plants, aggregating 21,000 lamps; between October and December, 29 additional plants. In Europe up to February, 1883, there were 108 Edison plants with 19,000 lamps. On May 31, 1883, we have a full list of the Edison isolated plants, showing 334 plants and 65,145 lamps. In 1884, the bulletins show another list giving 461 plants, with 84,000 lamps, showing a reasonably rapid growth of the business.

The bulletins also show that for central station lighting —these are isolated plants that we have been talking about —isolated plants are plants which are put in separate buildings, such as mills or the like, where the building has its own source of power, has a steam engine running its own dynamo. Central station lighting is a character of lighting where the apparatus for generating the current is located at a central station or building, from which wires diverge and enter houses, the user of the lamp having control only over the lamp itself. It appears by the bulletin for April 6, 1883, that a large central station plant in New York City had then been in operation with unvarying success for several months, without stopping one moment night or day. At that time the station was lighting 368 houses, wired for 8,000 lamps. On Oct. 31 of the same year the station was lighting 508 houses, wired for 12,000 lamps.

Since that time the business has grown to enormous proportions, the capital aggregating tens of millions investment in the manufacture and use of incandescent electric lighting apparatus, employing lamps manufactured by the Edison company or by infringers of the Edison patent.

At the present time the number of lamps alone of this kind manufactured throughout the world is, by a conservative estimate, between 75,000 and 100,000 lamps per day. Two thousand five hundred persons are employed alone in the United States in the manufacture of these lamps, and this is only one branch of the business which has been created by this invention. Edison's lamp factory alone employs 1,000 hands, and has a capacity of 25,000 lamps per day.

We therefore claim for the invention of Mr. Edison the merit of great utility, and for his patent that liberality of construction which the courts in the past have applied to patents upon inventions of this character.

The defendant's experts, your Honor, take the position that, in view of the state of the art, as shown by prior patents and publications, there was no invention required to produce the lamp of the patent in suit. In fact, both Dr. Morton and Prof. Cross, the defendant's experts, put themselves in the position of the intelligent artisan, as he is supposed by them to have existed in the year 1878, and state that if they had been asked to make a King lamp, or a Roberts lamp, or one of those of Sawyer and Man or Farmer, they would have produced the lamp of the patent in suit. If indeed they had not at once made the perfect and complete thing, the difficulties met with would have been remedied as they arose, they say, by an intelligent application of existing knowledge.

This position we would feel safe in leaving to the court without discussion, after directing attention to the literature which shows what skilled artisans, expert electricians and trained scientists, who must have possessed the knowledge of their time, yet didn't do the thing, thought of the matter as late as the date adopted by Prof. Morton and Prof. Cross for the existence of the complete knowledge which would have led, without invention, to the practical incandescent lamp, were it not that this affords a good opportunity for the criticism of these gentlemen as experts competent to instruct the court upon this subject.

These same gentlemen, when the necessity arose, as it did in the McKeesport case, for making a place in the art for the Sawyer and Man arch-shaped fibrous carbon, treated the prior art and the extant knowledge as entirely inadequate to supply a practical device. The prior art, according to their testimony in that case, did not supply a suitable carbon or a suitable lamp chamber, or a knowledge or appreciation of the conditions of practical success in the construction of incandescent electric lamps. From their point of view a gap existed in the art, and a very large one, which it was necessary to fill before incandescent lighting could become a commercial fact.

Judge Bradley agreed with them that the gap did exist, but decided that it was not filled by the arch-shaped fibrous carbon burner of Sawyer and Man, but by the filamentary burner and high vacuum of Edison.

Now that there is a change of attitude, and that their client has become the defendant, these same gentlemen find no difficulty in disagreeing both with their former testimony and with the decision of Judge Bradley, and now they say that there was no gap at all.

Aside from the question of the merits of this argument, which we would deem safe in leaving without comment, the inquiry arises whether these two gentlemen are not speaking as partisans and advocates, rather than as scientific experts sworn to inform the court as to the facts. If the former is true, what reliance can be placed upon any of the statements of fact or expressions of opinion given by these experts?

Dr. Morton's position in the McKeesport case was entirely inconsistent with his present attitude. That is shown by his testimony, and it is also shown by his article in *Scribner's Monthly* for August, 1889, which was published while Mr. Justice Bradley had the McKeesport case under consideration, and while the Westinghouse Company and its experts were still hopeful that Justice Bradley would adopt their view as to the inefficiency of the prior art and the sufficiency of the Sawyer-Man lamp for commercial electric lighting.

Your Honor will recollect the statement made in that article that Dr. Morton published in the *Scribner's Monthly* for August, 1889, while the McKeesport case was under consideration.

"The problem of commercial electric lighting by incandescent conductors yet remains without a solution. This was the state of affairs even up to the fall of 1878."

In that article, Dr. Morton follows the statement that this remained the condition of affairs up to the fall of 1878 by the further statement that Sawyer and Man at that point of time came in and solved the entire difficulty.

In the same paper he attempts to belittle the accomplishment of Mr. Edison in this respect, putting his lamp down as an improvement upon the Sawyer and Man construction, but making this statement to which we wish to appeal in the present case.

"It is to Mr. T. A. Edison, without doubt, that we owe many of the simplifications and modifications which, by cheapening the lamp and diminishing its weight, have extended its range of use and its usefulness to a remarkable degree."

Justice Bradley has removed Sawyer and Man from the prominent position in the art given them by Dr. Morton in his deposition in the McKeesport case and in his *Scribner* article; but we have left, both in his deposition and in that article, as a beneficial residuum, the opinions expressed by Dr. Morton that the problem of commercial electric lighting by incandescent conductors yet remained without solution; and that what Edison did extended the range of the usefulness of the electric lamp to a remarkable degree.

With respect to the value of the testimony of Prof. Cross, one of the two principal expert witnesses for the defendant, we feel called upon to remark that it appears by this record that Prof. Cross' opinions vary with a change of client and with a change of retainer. He was employed by the complainant when it contemplated bringing suit on the same Edison patent in the year 1881, against the same defendant and against the same lamp; that is, the M. lamp, which is one of those in this case, was the particular lamp that the complainant then contemplated suing the defendant for the manufacture, sale and use of.

His professional and paid-for report to the complainant in 1881 is not only entirely inconsistent with his present attitude, but when compared with the views he holds now it becomes interesting from a moral and psychological standpoint.

Referring to the report itself, we find it composed of a series of letters.

The first is a letter to Mr. Cross from S. B. Eaton, the vice-president of the complainant, dated May 17, 1881, sending him two Edison lamps and one Maxim lamp, and telling him that Mr. Betts, the counsel for the company, would write him at once the points of the opinion desired.

The next is a letter from Mr. Betts to Prof. Cross, in which the points of the opinion desired are set out, and it is stated:

"The first question which arises in connection with the United States company's lamp is the following: Is the carbon which is made incandescent in the United States company's lamp 'a filament of carbon of high resistance'"?—quoting the language of the first claim. "You will notice that Edison says in his patent that previous to this invention light by incandescence had been obtained from rods of carbon of one to four ohms resistance. It is clear that he means to say that such lamps were of low resistance, and that such 'rods' were not 'filaments.' The question is, What is the resistance of the carbon in the United States company's lamp, and is such resistance, whatever it may be, a *high resistance* in the sense of the Edison patent?"

Then we have a memorandum from Mr. Wilber, patent solicitor for the complainant company at that time, which accompanied the letter of Mr. Betts to Prof. Cross, referring to various patents and publications, and setting up the matter quite fully, and terminating with this statement:

"Mr. Edison would like Prof. Cross to investigate the subject and determine, if possible, what was the probable resistance of such incandescent electric lights as were described prior to 1879.

"If they were of low resistance (up to say two, three, four and five ohms), is the use of incandescing conductors of high resistance relatively thereto (15 to 200 ohms) a practical advance in the art of subdividing the electric light and fitting the electric light for use as a domestic illuminant, taking into consideration the distribution of a current on a multiple arc system?" "Is the Maxim United States lamp substantially identical with the Edison lamp?"

We have Prof. Cross' reply dated June 11, 1881: "The U. S. Co.'s lamp is undoubtedly a lamp of 'high' resistance as compared with lamps of 1 to 4 ohms resistance. The resistance of the lamp sent is 43 ohms. I should say that beyond a doubt it is a high resistance lamp in the sense of the patent."

And as to the sealing of the lamp, he finds that it is sealed in glass. That was a special point in the case.

So we have in Prof. Cross' report the conclusion reached, that this Edison patent described a practical advance in the art, that that advance in the art was made use of in the defendant's lamp, and that the defendant's lamp was a lamp of high resistance although only 43 ohms; that although the lowest resistance mentioned in the patent is 100 ohms, yet Prof. Cross thinks that the 43 ohms lamp of the defendant would be included within the scope of the patent.

His views upon that subject now seem to be entirely changed, if we can judge by what he says in his deposition in this case.

With regard to the construction of the patent itself, there is one point at least to which I shall briefly allude, although, from our point of view, it would seem to require no explanation. That is, as this controversy stands, upon the lamp which is here as an infringment. That is the question of the meaning of the term "filaments of carbon," which appears in all the claims as the descriptive expression of the burner of the lamp.

In the litigation over this patent, the attacks upon the patent have been directed to some considerable extent to that expression, "filament of carbon." In the English litigation the defendants contended that the expression was vague and indefinite and uncertain; and a great deal of the time was given, both in the arguments of counsel and in the opinions of the court, to the interpretation of that expression. Here we find the defendants repeating these attacks through their experts, and asserting that there is no test by which it can be determined what is a filament of carbon; and that such a determination is necessary, in order to exclude the old lamps and include the new lamps—that is, include the defendant's lamps.

The complainant's witnesses have been vigorously pressed on cross-examination to say what is the largest filament which would still be a filament and not a rod, and what is the smallest rod that would still be a rod and not a filament.

From the persistency with which complainant's witnesses were pursued on this topic, it may be that defendant's counsel proposes to argue that some such well defined line of demarkation must be fixed, in order to warrant the court in finding that the patent is valid and that the defendant has infringed.

We say that this mathematical certainty is not necessary, and may never become necessary, and certainly such a discussion ought not to occupy the time of this court until a lamp is sought to be enjoined under the patent which approaches the borders of the invention. So long as the lamps manufactured by the defendant which are in the case as the basis of the suit are of the disting-

tive filamentary character, have burners of extreme tenuity, there would seem to be no reason for a discussion as to how much larger these burners may be made and still be within the term of the patent. This is entirely a moot question, not before the court at all.

The defendants have suggested that the proper construction of the expression "filament" may be a burner of at least 100 ohms resistance hot. The hot resistance of a carbon burner is about one-half its cold resistance, carbon when cold measuring double the resistance of the carbon when brought to this state of incandescence.

It is not entirely certain that that means in the patent resistance hot; but the defendants stoutly assert it, and there may be the better reason for thinking that it does.

The M. lamp of the defendant has 40 ohms hot; the zigzag lamp has 80 ohms hot; the Tamidino lamp has 150 ohms hot. So you see that under that contention two lamps of the defendants would not infringe the claims, but the third would, the third having 150 ohms hot; and the object of that contention it might be well to refer to at once.

Under the present affiliations of the defendant with the Westinghouse Electric Company, a system has been introduced of distributing electricity by means of alternating currents under high tension or pressure. In connection with that system they use converters, as they are called, at the houses. The converter is a device which transforms that high tension current into a low tension current, from 1,000 volts of pressure down to 50 volts of pressure, and the converter itself forms an independent source of electricity, similar to a locally placed dynamo. The wires from the converter pass into the house and the lamps inside of the house are connected in multiple arc with those wires.

Now, the distance that the wires run from the converter not being very great, only being the distance from the street throughout a building, large or small, it is possible to use lamps of somewhat lower resistance than can be used by a direct system; that is, instead of using 100 volt lamps, as we do, or lamps with about 250 ohms resistance hot, they use 50-volt lamps, lamps which have less than 100 ohms resistance, probably 60 or 70 ohms resistance. So that if the defendants succeed in that contention, although they will not escape the charge of infringement in this particular case, having a lamp here which is more than 100 ohms, yet they will practically escape the charge of infringement in the future, because they will be enabled to go on with their business under the converter system and use lamps of less than 100 ohms hot.

As to the evidence in the patent itself of this matter of 100 ohms, this is a mere expression of what Edison had observed, we take it, when he said he could get 100 ohms in one way, 100 to 500, and 2,000 ohms by another way, etc.

The patent is not limited to any particular length of the filament. We might cut the filament to different lengths. Cut it in half and we would have half the resistance and we would have half the radiating surface. But the Patent Office model shows what Edison contemplated under that patent, and the drawing of the patent shows what he contemplated. The Patent Office model was examined by an expert lamp manufacturer, and we had that man make a lamp having the proportions of the Patent Office model and the electrical condition of it, and it measures in the neighborhood of 80 ohms cold and 40 ohms hot, being a lamp practically of the same resistance as the defendant's M. lamp, about which this question arises; and the same Mr. Howell, measuring the drawing of the patent in suit, finds that a burner made with the size shown in that drawing, of tar putty, which is the material that is supposed to be represented there, would have a resistance of 25 ohms cold or 12½ ohms hot, showing that we have in the drawing of the patent and in the model of the patent evidence which contradicts any such construction as that the defendants attempt to place upon that casual expression in the patent, or that statement in the discovery of the patent.

When we follow this argument of defendants' experts with regard to the necessity for 100 ohms hot, in order to use lamps in large numbers in multiple arc, we see that the logical conclusion is this: There is no particular efficacy in 100 ohms as distinguished from 90 ohms. It appears by the testimony of two of the defendants' witnesses, all of the defendants' witnesses in fact, that not even 100 ohms is sufficient to fulfill the conditions which they impose upon the patent, and that no lamp made at the present day would fulfill those conditions. Not even lamps of 250 ohms resistance could be used in large numbers in multiple arc in accordance with the construction which the defendants' experts place upon that expression.

Your Honor will recollect that Prof. Cross said that this lamp of 40 ohms resistance which he had before him, which was one of these M. lamps of a still lower resistance—that that was a high resistance within the terms of the patent. Now there is nothing in his explanation of why he has changed his views on this subject that would give any real ground for that change. I recollect that he said something about not knowing about the Lane-Fox patent at the time he made that report. That, so far as I recollect without consulting the record, was the only reason he gave. What has that got to do with it? Lane-Fox had a platinum lamp, it is true; Lane-Fox appreciated the necessity of high resistance; but he didn't have a resistance less than 100 ohms. Such high resistance as he had was a high resistance of over 100 ohms. He simply appreciated the necessity for it.

There is nothing in the Lane-Fox patent to warrant a distinction of under 100 ohms as distinguishing under the Lane-Fox patent; that is to say, the defendants' position does not amount to a distinction under the Lane-Fox patent, and there would seem to be no reason for the change in Prof. Cross' attitude on this subject due to a lack of knowledge of the Lane-Fox patents at the prior time and a full knowledge of them at the present time.

The difference between the filament and a rod is one which is not so apparent to the eye as it is to the touch of the electric current. Comparing two burners of circular cross section and of the same length, one having twice the diameter of the other, the smaller burner will have one-quarter the cross-sectional area by reason of being one-half the diameter, will have four times the resistance and one-half the radiating surface, and since the increased heating effects of the higher resistance are augmented by the increased temperature due to the smaller surface, it will be seen at once that small changes in diameter, not readily appreciated by the eye, produce large differences in the ability of a burner to give light economically. A difference of one-half in diameter is an enormous difference electrically when we consider that it makes a difference of four times in resistance and one-half in radiating surface, both of those changes acting in the same direction to produce economy in the light; that is, to produce a large light or a good deal of light with a small expenditure of coal at the steam engine.

For the purpose of calling attention to the differences between filamentary lamps and the rod lamp, shown by the record, we have prepared a couple of tables describing a number of these burners, and giving their dimensions of cross section, resistance and radiating surface, and the ratios by which they may be compared.

So far as we have investigated the record down to the present time, by means of this opening presentation, it would appear that Mr. Edison was entitled to a broad claim for the combination of a carbon burner without regard to its dimensions with a vacuum chamber of this particular character, and we think that, notwithstanding what I am about to speak of, he is still entitled, or would have been entitled to a claim of that kind.

The real scope of his invention was broader than the filament. The filament, however, was the particular form that it was necessary to put the burner in, in order to make it a success. The patent is limited to that, or describes that; but we think that, under the circumstances of the broader invention being his, based upon the discovery of the stability of carbon, a liberal construction should be given to the claim.

At the last moment, when the complainant had nearly finished the taking of its rebutting testimony the defendants found that somebody else had in this country made what they saw fit to call a lamp having a carbon burner in this kind of a chamber, 10 years before Mr. Edison made this discovery and invention. That was the lamp of Dr. Isaac Adams, the inventor of the nickel-plating process.

There is no doubt but what that was an absolutely abandoned experiment. I will not dwell upon the particulars of it. I simply call your Honor's attention to it so you will have it in mind in the consideration of the case.

No sample of this lamp or supposed lamp was preserved; no publication of it was made. Adams applied for a patent in 1882, long after the Edison patent had been granted, and being rejected on the Edison patent, accepted that rejection and avoided the terms of the Edison patent by limiting his claim to particular things. We simply wish to call your Honor's attention to the fact that, whatever this lamp might have been, it is evidently wrong in principle, being a lamp of a large radiating surface and a low resistance.

Indeed it appears that Dr. Adams was not interested in the thing as a lamp at all. He was simply interested in it as a device enabling him to seal large platinum wires into glass. He was a constructor of Geissler tubes, the only expert constructor of Geissler tubes who has testified in this action. They say that the skill possessed by constructors of Geissler tubes would have enabled anybody to seal wires into glass. But as shown by the evidence of Dr. Adams, a long course of experiment was necessary. His skill as a constructor of Geissler tubes did not enable him to seal the wires in; but it was only after a long course of experiment, by the discovery or production of a peculiar glass composition, which it appears he did not disclose to anybody at the time, and did not disclose until his patent of 1882, that he was able finally to seal these wires into the glass.

What he attempted to do was to seal into glass wires big enough to carry the current to the old rod burners. He attempted to adapt the Geissler tube to the principle of the old lamp.

Edison changed the principle of the lamp and made it possible to apply the Geissler construction to it with the ordinary skill at that time possessed by constructors of Geissler tubes.

There are a number of matters, your Honor, that I could touch upon; but probably without benefit to the case, at least at this time of the argument, and if I have succeeded in my argument in clearing away some matters of detail which were obstructions in the line of sight, so that the argument may be carried forward from this time with less labor on the part of both the court and counsel, I feel that I have been successful in performing my duty.

I only wish to say in conclusion that with a case such as we think the facts present here, we feel that we are entitled to the favorable consideration of the court.

Giles Steel Railway Poles and Brackets.

The Giles steel railway pole is made up of four angle sections, forming the four corners of a square, and to resist the pull of the span wire is a simple matter of making these angles of sufficient size and weight to furnish the required cross section. The pole, being square, offers as much resistance to pull in one direction as in another. At the grade line, where the chief trouble has been with many poles, the angles are separated by two large plates. These poles can be set to pull against a stone or other solid packing at this point without danger of crushing. The design of the pole, as will be seen from the illustration, is neat and light, tapering evenly from the ground up, and as it is latticed and open it does not present as clumsy an appearance as a solid pole. The pole is especially designed for the heavy strains met with in double-track and curve work.

The Giles steel railway bracket is of the best lap or butt welded steel tube held in place against the lower plate of the bracket by a wrought-iron clip riveted to it. This plate is clamped to the pole, no screws or spikes being necessary, and is of such size and shape as will allow of ready attachment to poles of different diameters. The load is directly supported by two truss rods of steel, which pass on either side of the pole and are attached to a heavy bar or plate. They are provided with thread or nut, by means of which the height of the arm is adjusted. A smaller rod is run on the under side of the arm, which prevents a raising of it by the passing under of the trolley. It is claimed that this is a rigid bracket, free from swaying motion, lifting or springing, and superior to those made wholly or in part of cast iron. They are made of first-class materials, and are fully guaranteed. The poles and brackets are handled in the West exclusively by the Illinois Electric Material Company, of Chicago. This bracket was illustrated in The Electrical World of April 18, 1891.

It is worthy of remark in this connection that much of the rapid progress of the electric railway industry has been due to the excellent material which has been furnished by manufacturers whose long experience in the construction of similar materials for other work made it possible to at once supply whatever was best adapted to the needs of the railway business.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

Westinghouse.—At the end of last week nearly 80,000 shares of Westinghouse stock had been deposited under the reorganization plan.

The Commercial Cable Company will pay a quarterly dividend of 1¾ per cent. July 1 from the net earnings to holders of record June 20.

The Pettingell-Andrews Company has declared a quarterly dividend of 2 per cent., payable July 1 to stockholders of record June 20, books being closed between these dates

European Electric Welding.—It is officially stated that the European Electric Welding Company has received £10,000, in two installments, on account of the balance due by the British Company, on May 21, £5,000, and on June 1, £5,000, together with interest due for the time deferred. The annual meeting has been announced for June 10, at Portland, Me.

Tropical American Telephone.—Below is a statement of assets and liabilities of the Tropical American Telephone Company as of date Jan. 1, 1891, which has never been published:

ASSETS.	
Bills receivable	$30,999.36
Merchandise on hand	11,400.00
Treasury stock, 3,000 shares	3,000.00
Cash in bank	8,232.14
	$53,631.50
LIABILITIES.	
Bills payable	$ 2,505.39
Balance of assets	$51,126.11

In this statement patents, contracts and franchise are given no value. The capital stock of the company is $400,000, of which 37,000 shares are issued, par value $10. The company's sales last year were more than $1[illegible]0,000, and the sales for the six months to Jan. 1 more than $56,000.

Mexican Telephone.—The annual report of the Mexican Telephone Company for the fiscal year ended Feb. 28, 1891, shows: Gross receipts in Mexico, $74,068.79; gross receipts in Boston $18,460.06; cash balance from previous year, $5,273.86; total gross receipts, $99,802.71; increase for the year, $21,909.16. Disbursements in Mexico, $60,150.85; in Boston, $26,560.78; cash balance on hand, Boston, $12,100.19; in Mexico, $990.89, total, $99,802.71. Increase in expenses for the year was $18,071.30; deduct extraordinary expenses, $14,800; net increase, $3,271.30. Total receipts in Boston for the year (including a cash balance of $4,257.16), $38,660.97; total disbursements in Boston for the year, $26,560.78; leaving cash balance in the treasury of $12,100 19. Net receipts were $12,594 97 in the year ended Feb. 28, 1891, against $16,532.15 and $982 46 in 1889 90 and 1888-89 respectively. The report says: "Our instrument and rental account shows a good, healthy growth. In February, 1890, there were 999 instruments in service, at a monthly rental of $4,917.50, not including 46 instruments at the Vera Cruz office, which was established during the month. In February, 1891, there were in service 1,123 instruments, at a rental of $5,623, which is an increase of 124 instruments as compared with the month of February, 1890 and of $708.50 per month in rentals. The extraordinary expenses of the year were the following: First, the settlement of the Crawford suit, $1,500; second, reorganization of Mexico office (about), $3,500; third, expenses connected with renewal of concessions, $1,000; fourth, bills payable from former years, $8,800. Total, $14,800. Extraordinary receipts were: From the Chihuahua and Durango settlement, $8,000. Excess of extraordinary expenses above such receipts, $8,800." The report of Robert Colgate, president, notes the compromise of the Crawford suit for $1,250; the decision in the company's favor of the patent suit; the settlement with the Chihuahua and Durango companies for $8,000; the liquidation of all outstanding obligations save that of the American Bell Company and the settling of claims against sub-companies. Two years ago the company was heavily in debt and was borrowing money at rates as high as 2 per cent. per month. At present the company has no outstanding debts whatever, with the exception of the unsettled claim of the American Bell Company. Its lawsuits and claims have all been satisfactorily settled, and there is a balance in the treasury of $12,100.19, with monthly remittances of from $1,500 to $2,000 coming to the home office regularly.

The Closing Quotations of electric stocks, from F. Z. Maguire & Co., electrical securities, 18 Wall street, New York, on Saturday, June 6, 1891, in New York, Boston and Washington were:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	80⅝	81
American Telegraph & Cable	100	14,000,000	80	80½
Central and South American	100	5,000,000	135	142
Mexican	100	2,000,000	200	215
Commercial Cable Co	100	7,716,000	105	106½
Postal Telegraph Cable	100	5,000,000	30	32
Edison General Electric Co	100	9,503,500	99	101
" " Deferred	100	2,496,500	....	....
Consolidated Electric Light	100	1,929,400	....	....
Edison Electric Illuminating Co	100	2,567,800	76	....
United States Electric Light	100	1,500,000	30	....
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	41¾	....
" " preferred	25	4,000,000	....	....
" " Series C	10	400,000	....	....
" " Series D	10	120,000	7	7⅛
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1,000,000	....	....
" European Welding Co	100	1,000,000	....	60
Ft. Wayne Electric Co	25	4,000,000	11¼	....
Westinghouse Electric Co	50	5,000,000	13¾	13¾
Detroit Electrical Works	..	....	10¼	10½
Telephone:				
American Bell	100	12,500,000	....	197
Erie	100	4,800,000	48	48¼
New England	100	10,304,600	50	....
Mexican	10	1,280,000	1.32½	1.35
Tropical American	10	400,000	87½c.	....
Edison Phonograph Doll	10	1,000,000	50c.	1.00
WASHINGTON.				
Pennsylvania Telephone	50	750,000	24	....
Chesapeake & Potomac	100	2,650,000	62	65
American Graphophone	10	600,000	5¾	7
United States Electric Light (Washington)	100	300,000	155	160
Eckington and Soldiers' Home Electric Ry	50	352,000	49¼	....
Georgetown and Tennallytown	50	200,000	57	65

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$230@$240	Cumberland	$60@ $62
Central Union	51@ 55	Wisconsin	118@.120
Michigan	84@ 85	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell	40@ 43		
ELECTRIC LIGHT STOCKS.			
Chicago Arc Light and Power	$103@$104	Chicago Edison Co.	$145@$150

AFFAIRS OF THE COMPANIES.

The Cairo (Ill.) Electric Railway Company has certified to a decrease of its capital stock from $150,000 to $75,000.

The New Albany (Ind.) Electric Light, Heat and Power Company, with a capital stock of $75,000, has made an assignment.

The Montclair (Col.) Electric Light Company has filed notice of the increase of capital stock to $50,000, and also a certificate of paid up stock.

The Peru (Ill.) Electric Light and Water Supply Company has sold out to the city of Peru for the sum of $16,000. The city takes possession about July 1st.

The Texarkana (Ark.) Electric Light and Gas Company has been purchased by the local syndicate headed by Mr. M. P. Hillyer. The purchaser will take charge this month.

The Santa Fe (Cal.) Electric Light Company held its annual meeting of directors recently and elected F. T. Webber president, to succeed E. T. Webber, Denver, Col., resigned.

The Edison Electric Company, of Oakland, Cal., has secured the plant of the Oakland (Cal.) Electric Light and Motor Company, and will probably be a competitor for lighting the city.

The Pruyn Manufacturing Company, of Troy, N. Y., issued a call last week for a meeting of its stockholders to consider the advisability of increasing its capital stock from $50,000 to $110,000 and engaging in the manufacture of the Winkler motor and other electrical apparatus.

The Electric Light and Power Company, of Helena, Mont., has elected the following board of directors and officers: S. H. Velie, Jr., president; B. R. Fitzpatrick, vice-president; L. Lucy, treasurer; Eli Newman, secretary; S. H. Velie, Jr., Jas. Summers, M. Newman, B. R. Fitzpatrick, J. Trieber, F. B. Sliger and W. M. Neal, directors.

The International Telegraph District and Construction Company, of Baltimore, Md., has admitted its insolvency and has consented to the appointment of receivers. Messrs. James B. MacNeal, Robert D. Morrison and A. de Russey Sappington were appointed by Judge Duffy receivers of the company. The appointment was made under the creditor's bill filed by William J. Chapman.

The Brush Electric Light Company, of Baltimore, Md., met last week and elected the following directors: Dr. Wm. Whitridge, Edgar G. Miller, F. G. Waters, James E. Hooper, F. G. Hibbard, of New York; H. C. Tudor, Lloyd L. Jackson and Summerfield Baldwin. The report of the officers to the company is said to show that the business is in a satisfactory condition. There was not a large individual attendance, but the stock was largely represented. No general manager was elected, and it was stated that none is necessary. The Westinghouse interest has attained a representation in the board of directors. There will be some changes in the officers when the board of directors meet, but Mr. Baldwin will be continued as president.

NEW INCORPORATIONS.

The Snohomish and Port Gardner Electric Company has been incorporated at Snohomish, Wash., with a capital of $1,000,000.

The New York Light and Power Company has been incorporated, with $50,000 capital. Among its incorporators are James Stephenson, Martin B. Brown, James A. Flack, J. H. Crane, and Charles S. Heins.

The Winters Electric Company has been incorporated at Chicago, Ill., with a capital stock of $10,000, for the manufacture of electric appliances. The incorporators are: F. M. Winters, A. F. Raymer and A. H. Baldwin.

The Electrical Supply Company, of Tacoma, Wash., has been incorporated to deal in electrical machinery and supplies, with a capital of $5,000. The incorporators are Henry Hutton, L. B. Lockwood and Charles D. Fratt.

The Lincoln Water, Light and Power Company, of Chicago, has been incorporated to build water-works, electric light plant and street railway. The capital stock is $250,000. The incorporators are E. D. Blinn, J. F. Mundy and D. C. Turley.

The United States Electric Company, of Chicago, Ill., has been incorporated, with a capital stock of $10,000,000, to manufacture electrical machinery, instruments and appliances. The incorporators are: Robert J. McIntyre, James B. Keogh and Robert B. Kendall.

The Oxy-Hydro Carbon Light, Heat and Power Company has been incorporated at Camden, N. J. The objects of the corporation are to manufacture machinery and erect the same for furnishing light, heat and power. The capital stock is $1,100,000, and the amount paid in is said to be $100,000. The incorporators are Joseph P. Lance, W. S. Wreford, Henry Steck and Charles Lance, of Philadelphia; Francis M. Gardner and Alexander Gray, of Camden, and W. L. Lance, of Whitings, N. J.

The Private Line Printing Telegraph Company has been incorporated at Albany, N. Y., with a capital of $25,000. The company will operate lines of telegraph from New York City along all railroads and other convenient ways and courses to Albany and Buffalo and intermediate cities and villages in New York State, and also from New York City to points on Long Island, Jersey City and Staten Island, and also lines from New York City to connect with all cities and towns within 33 miles of the City Hall, New York, in all directions. The directors are William H. Hurst, Eugene Darwin, John J. Walsh, Adolph G. Hummel and Edward J. Murphy, of New York City; Emil A. Wirsching and Frank A. Graham, of Brooklyn.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, June 8, 1891.

Mr. W. S. Norman, of the Edison Illuminating Company, Spokane, Wash., is in New York.

The Complete Electric Construction Company has removed to 10 Cortlandt street, New York.

Mr. Henry B. Cram, of the Bernstein Electric Company, Boston, dropped in to see his old friends in the city during last week.

Mr. F. G. Patterson, of the Denver and Lookout Mountain Resort Company, and who is also interested in the electrical industry, is in the city.

Messrs. W. H. Gordon & Co., through Mr. F. H. Sparline, received some large orders for Simplex wire and other specialties from their Northwestern friends, who have been in New York during the past few days.

Mr. F. H. Osgood, of Blaine, Wash., and Victoria, B. C., who is interested in several different electrical companies, was a visitor to New York last week.

Dr. E. C. Kilbourn, president and general manager of the Home Electric Company and the Seattle Electric Railway Company, of Seattle, Wash., was in town last week.

Visitors to New York this Week: H. T. Paiste, of Philadelphia; A. L. Daniels, Eureka Tempered Copper Company, North East, Pa.; W. C. Bryant, Bryant Electric Company, Bridgeport, Conn.; F. H. Leonard, Electric Engineering and Supply Company, Syracuse, N. Y.

The Equitable Manufacturing and Electric Company has opened offices at 44 Broadway, New York City, with Mr. D. H. Bates as general manager. The company will shortly introduce some new and valuable inventions in an important branch of the electrical industry.

Messrs. Einberger & Adler, of New York City, have met with the best of success with their new annunciators. The one of 300 calls at the Gilsey House is working admirably. They are now making one of 400 calls for the Grand Union Hotel, and expect to have it installed in a few days.

Mr. C. H. Philbrook, who has represented the Thomson-Houston Electric Company in Western New York for the past eight years, will hereafter act as traveling agent for the Aluminium Carbon Company, of Buffalo, N. Y. This company is now about ready to push its business, and will make a very superior line of carbons.

Mr. A. F. Stanley, president of the well-known firm of Stanley & Hall, this city, will be united in marriage with Miss Mildred Beckwith Knapp on Wednesday, June 10, at Netherwood, N. Y. After the ceremony they leave for an extended trip to Montreal, Quebec, the Thousand Islands, Niagara Falls and Chicago. Congratulations.

Mr. W. S. Chesley, the well-known supply dealer, with offices in the Electrical Exchange Building, has in stock about every variety of motor and dynamo, wires of all kinds—in fact, anything that has any sale in the electrical field. Mr. Chesley is meeting with good success, having sold 25 motors and a large quantity of wires this week.

The Ball Electric Light Company, of Twenty-seventh street, New York City, has lately been making some large shipments of its dynamos, notably to New Orleans, Bay St. Louis, Lake St. Charles, La., and other Southern and Western points. The Ball system, wherever used, is giving the best of satisfaction and the company is rushed with orders.

The Central Electric Company, of Chicago, has secured the Western agency of the "Bryant" double pole switches and other specialties manufactured by this company. As the Bryant company manufactures a superior line of goods, these will be a valuable adjunct to the central company's specialties and will no doubt result in large profits to all concerned.

The Eureka Electric Company, of 18 Broadway, N. Y., is installing a 600-light Loomis dynamo at the Homeopathic Hospital, Middletown, N. Y.; 250 lights for the Gastonia Cotton Manufacturing Company, Gastonia, N. C.; and has shipped to the West this week a 900-light Loomis dynamo and fixtures. Business with this company continues good, and its system is constantly growing in favor wherever used.

Mr. W. F. D. Crane became associated with the Engineering Equipment Company, of 143 Liberty street New York, on June 1. Mr. Crane will give his time principally to the continued development of the company's growing business in the Anderson trolleys, line materials, etc, the Kellogg combination steel centre and side poles and other equipment materials for electric railways, and engineering works in general.

The Engineering Equipment Company, of Liberty street, New York, has opened a branch office at 126 Pearl street, Boston, with Mr. F. A. Magee, formerly with Messrs. E. S. Greeley & Co., in charge. The company will carry a full line of the Underwood Manufacturing Company's celebrated belting, Anderson trolleys and specialties, Dodge wood pulleys, indurated fibre pipe, etc. Mr. Magee is so well known to the trade that the new England office ought to prove a very profitable one.

Ward Lamps.—The demand for Ward lamps, manufactured by the Electric Construction and Supply Company, of 18 Cortlandt street, New York, has been so large in the West that the company has opened an office in the Phœnix Building, Chicago, and Messrs. McDougall and Cummings have been appointed Western managers. The company has been in receipt of some very large orders during the last few days, many of them duplicates, showing a growing popularity of this type of lamp wherever used.

The Hunt Engineering Company, of 238 Washington street, Brooklyn, N. Y., has acquired the agency for the Buckeye Electric Company, manufacturers of incandescent lamps, having appointed Mr. E. W. Hickcox as their general salesman. Mr. Hickcox was formerly the eastern agent for the Buckeye company, with offices at 120 Liberty street, New York City. The company is to be congratulated in securing this agency, as the Buckeye lamp is certainly among the very best on the market. Both offices will now be used in the interest of the Hunt Engineering Company.

National Electric Light Association.—A meeting of the Executive Committee of the National Electric Light Association will be held at Montreal, Canada, to-day, to arrange details for the coming convention. An unusually active interest is being taken this year in the Montreal meeting, and it looks very much as if the attendance and objects of interest displayed would equal and even exceed those of former conventions. The immense Victoria skating rink at Montreal will be used for the purposes of the Exhibition, as it has been found that a smaller hall would not be sufficiently large to accommodate the many who are anxious to obtain space.

Capt. Samuel Brown, the famous turfman and coal baron, has been experimenting for some time through the Electric Mining and Machine Company, of Pittsburgh, for the purpose of developing an undercutting machine operated by electricity for use in his own mines in Pennsylvania. During this time he has bought a number of patents, built machines of all types, using motors of various make, besides erecting a power station, where sufficient current could always be had. Recently, he engaged Mr. Robt. M. Lloyd, of Lloyd & Paxton, Limited, to design a motor especially adapted for working undercutting machinery. The machine has been running for the last few weeks, and has been cutting coal so well that Captain Brown has decided to build a factory in Pittsburgh, where these machines will be built for the trade. The motor and coal cutter combined weigh only about 1,000 pounds. Mr. Lloyd has been experimenting in this line for a number of years, and the result of his labors shows a machine with many unique features.

The Franklin Experimental Club held its thirty-third regular meeting last week at the club laboratory in Newark, N. J., and two very interesting papers were read. One was presented by Wm. J. Hammer and was entitled "Some Facts and Phenomena about Incandescent Lamps." Mr. Hammer gave a most explicit account of the points of manufacture in the modern incandescent lamp, and also brought in some interesting prophecies for electrical heating and cooking. The second paper was presented by Mr. Earl Atkinson, and entitled "Electric Motors." Mr. Atkinson first took up the subject in a general way, describing the more recent achievements and the present state of the art. He said that while the tendency was toward larger motors in some cases, in others it was toward large numbers of small motors, as, for instance, in certain lines of manufactures where each machine was provided with its own separate motor. He then took up the questions more particularly involved in the design and construction of street car motors. L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 8, Cook Building, cor. Franklin and Congress Sts.,
BOSTON, Mass., June 6, 1891.

The Thomson-Houston Company is building a freight locomotive of 60 h. p. at the works at Lynn, Mass.

The Biddeford and Saco Horse Railroad Company is to equip its line with electricity the coming season.

The Essex Electric Company has been refused the privilege of running its cars to the "Willows," by the board of aldermen, at Salem, Mass.

Mr. E. F. Dean, of the Manchester, N. H., electric light service, is to be superintendent of the new fire alarm of that city, which is now completed.

Colonel Burnham, of the Electric Gas Lighting Company, has arrived home from his extended trip to the South and West with his pockets full of orders, as usual.

The Massachusetts Manufacturing and Electrical Supply Company has located in Chelsea at 163 to 171 Marginal street, where it has more facilities, and is prepared to manufacture everything in the way of bells, push buttons, cleats and all kinds of electrical woodwork and supplies.

The Bell Rock Electrical Conductor Company last week gave an exhibition of the working of its new machine for covering wire with lead. The wire is first covered with cotton, then the lead is put on under hydraulic pressure, making a very substantial as well as a durable article. The machine has a capacity of about 12 miles of wire per day.

Messrs. Whitemore & Robinson, Electrical Engineers, have recently fitted up a laboratory at 133 Essex street, this city, for the purpose of doing all kinds of testing and calibration. Their laboratory is furnished with the latest and most approved instruments, and both members of the firm are well fitted by long experience with the leading electrical companies in the country for this work.

Governor Russell has signed what is called the Municipal Lighting act. This act permits all cities and towns in Massachusetts to supply their own gas or electric light from their own plants. The profits from such lighting must not exceed eight per cent. per annum. The act has been passed and signed after persistent and heated agitation covering a period of over two years. It makes it obligatory on the part of cities and towns to purchase existing plants or such portions thereof as may be found suitable, and in case a single corporation in a city or town owns and operates both electric light and gas plants the purchase shall include both at an estimated market value. C. A. B.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 CITY TRUST BUILDING, PHILADELPHIA, June 6, 1891.

Pittsburgh is now enjoying a three-cent car fare rate, the Pittsburgh Traction Company having reduced the fare on its lines on June 3, and as a consequence travel is very heavy upon this road. The other lines running to the East End district of the city have not yet met the rate of the above company. The Duquesne Traction Company has been having a good deal of difficulty since starting, having some heavy grades to overcome. The motors have not been at all times equal to the task of taking the large cars up these grades. However, there is a gradual improvement taking place, and it is the hope of the Duquesne management that ere many weeks everything will be running smoothly. An interesting case has just been argued in the Pennsylvania Supreme Court at Harrisburg, Pa. It was that of the Northern Electric Light and Power Company, which claims to fall within the exemption of manufacturing corporations from taxation of its capital stock. Judge Simonton, of the Dauphin County Court, had decided that "electric light companies are not manufacturing corporations, because they do not manufacture any material substance, electricity being intangible, and nothing but the undulations of luminiferous ether." The counsel for the company said that the legislature had authorized the incorporation of companies for the express purpose of manufacturing electric light. Scores of charters have been granted for that purpose. Within a few days the Governor had signed a bill authorizing a borough to manufacture electricity. Modern definitions of manufacture extend the term to every artificial product of human invention, skill and industry, whether tangible or intangible, and electric light is commonly spoken of as a manufactured article. Attorney-General Hensel said in reply that there could be no process of manufacture, unless as the result of the company's operations something which is clearly a material substance is produced.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, June 6, 1891.

Mr. Thomas D. Lockwood, of Boston, Mass., is favoring Chicago with his genial presence this week.

Mr. W. L. Scott, president of the St. Louis Electrical Supply Company, is purchasing supplies in Chicago this week.

Mr. George A. Hamilton, of New York City, and Mr. H. C. Sprague, of Kansas City, are welcome visitors in Chicago this week.

The Illinois Electric Material Company, of Chicago, Ill., is in receipt of the orders for the complete overhead equipment of two street railway lines.

The Electric Merchandise Company, of Chicago, Ill., has secured the contract for the overhead equipment of the electrical railway at Williamsport, Pa.

Mr. F. W. Weir, the Chicago manager of the Falls Rivet and Machine Company, has secured the contracts for the transmission machinery in the electric lighting plant in Lincoln, Neb.

The Chicago Electric Manufacturing Company, 73 West Jackson street, Chicago, has added a calibrating department, and is now fully equipped to adjust and calibrate testing instruments between wide ranges, even up to 1,000 ampères. The

brating department will be under the charge of Mr. E. W. Hammer, who will also look after the repairing of fine testing instruments.

Mr. J. W. Mason, formerly manager of the Gate City Electric Company, has secured the agency of the Safety Insulated Wire and Cable Company, and is now located at 515 Main street, Kansas City, Mo.

Mr. George L. Kirkham, general manager of the Northwestern Electric Specialty Company, Chicago, has met with remarkable success in introducing the Economic incandescent lamp in the West, where it is now in daily use in ten different States, and by a system of judicious advertising and the mailing of sample lamps the number of orders received is daily on the increase.

Mr. C. A. Brown and Mr. Ernest Warner will s. ortly invite their friends to join them in the enjoyment of a ride on the lake in their handsome new sloop-yacht, "The Phantom," which is being fitted up in modern style, and as it is 42 feet in length will easily carry a party of a dozen or more friends. The yacht will be quartered near Lincoln Park, and the skipper is an experienced lake captain.

Force Bain, 47 Jefferson street, Chicago, is equipped to manufacture electrical apparatus to order on short notice and has just completed several dynamos and motors of special design. Employing only modern machinery and skilled labor, he is enabled to turn out the highest quality of work promptly. He is now engaged in building to order some small incandescent dynamos for residence lighting, to be driven by oil or gas engines.

Mr. R. P. Pierpont, the Western agent of the Gould and Watson Company, of Boston, Mass., has moved into the handsome suite of offices, No. 314 Northern Building, Chicago, Ill. Mr. Pierpont has found a ready sale for the molded mica specialties, and has recently received large orders for the keyless socket for incandescent lamps, which has the wire molded into the socket in such manner as to make the socket waterproof on top, while the fitting of a rubber ring closely between the lamp and inside of skirt prevents moisture from getting below.

Valuable Collection of Portraits.—The photographs of one hundred gentlemen prominent in the electrical fraternity have been neatly framed and placed in the Western office of The Electrical World, where they are attracting much attention. It is the hope of the collector that these photographs will form the beginning of a complete collection of portraits of all who are or have been identified with the progress of electricity in any of its branches, and that a suitable place may be found for the entire number in the electrical section of the World's Fair.

South Chicago (Ill.) City Railway.—An ordinance was introduced at the council recently granting to the South Chicago City Railway Company the privilege of running an electric road in Chicago. The ordinance grants permission to the company to construct and maintain tracks on the following routes: From the intersection of Commercial avenue and Ninety-second street north on Commercial avenue to Seventy-ninth, thence to the middle of Coles avenue; another on Commercial avenue from Seventy-ninth street to Cheltenham place, along Cheltenham place to the middle of Coles avenue; another from the intersection of Ninety-second street and Buffalo avenue to Eighty-seventh street, thence to Superior avenue and to Eighty-third street, on Eighty-third street to Ontario avenue, thence to Ninety-ninth street, and from there to the middle of Coles avenue, from there to Seventy-first, via Yates avenue to Sixty-eighth street; another from the intersection of Ewing avenue and 106th street and Indiana avenue. F. de L.

ENGLISH NOTES.

(From our own correspondent.

London, May 27, 1891.

Central London Railway Bill.—This bill, as you may perhaps recollect, passed through the House of Commons some few weeks ago and will shortly come before the House of Lords, where the prospects of its success seem decidedly good. The time for lodging petitions against it has expired and only ten have been sent in, none of which offer any serious opposition to the bill. Four are new, deposited by owners of property, whilst of the remaining six only two appear likely to be vigorously supported. The City of London authorities, who opposed the scheme in the House of Commons, have now presented a petition against any alterations being made in the bill.

Search Lights as a Means of Naval Defence.—In a recent paper on what is to naval men the engrossing subject of ships versus forts the author described a number of instances which were afforded by your own civil war of ships forcing narrow passages at night-time and drew a terrible picture of the difficulties of such a feat if added to big guns and torpedoes the ships encountered the pitiless glare of innumerable search lights. The deduction arrived at was that for coast and harbor defence a little less money spent on big guns and a little more on large search lights would be distinctly advantageous. A striking testimony to the value of the search light as a means of defence was involuntarily given but a few weeks since by the French navy, During some naval manœuvers at night off Cherbourg, the torpedo boat "Edmond-Fontaine" was run down by a large cruiser whose captain was completely dazzled by the rays of a hostile search light.

City & South London Railway.—Although this company's train service has now been in regular operation for nearly six months, no steps have as yet been taken to improve the somewhat defective ventilation and the decidedly defective lighting both of the stations and the trains. The result is apparent in the marked influence which the weather has upon the weekly traffic receipts. Whenever we are indulged with a little sunshine and warmth, down go the weekly earnings of the company, and a return of wintry weather is immediately followed by a return to winter receipts. Indeed a chart of this company's weekly traffic returns would prove quite as accurate a record of the general state of the weather as a file of the daily prognostications of the meteorological office. A little money spent in minimizing these two defects would, I think, result in the income of the company being much the same during the summer as during the winter, since well-lighted cool stations and trains would be as welcome a refuge from the heat of the sun in summer as the comparative warmth of the tunnels is in winter from the cold and damp.

Municipal Electric Lighting.—A good example of the ineptitude which as a rule characterizes municipal dealings in connection with the electric light has recently been afforded by the action of the Cambridge Town Council. They secured the services of Dr. Fleming in the capacity of consulting engineer and he naturally advised the employment of the alternating current transformer system of distribution, the lighting being likely to be of a very scattered character. The tenders sent in were, however, all considerably in excess of the estimate formed by Dr. Fleming, and in consequence the electric lighting committee of the Town Council appear to have jumped to the conclusion that there was something radically wrong with the system recommended, and proceeded immediately upon a tour of inspection. Newcastle was visited and steam turbo-dynamos were seen at work. The compactness of these and the makers' sanguine claims of efficiency, economy, etc., completely convinced the visitors that they had, so to speak, "struck ile." They returned to Cambridge pompously announcing the discovery of an entirely new system, specially suitable for Cambridge. Steam turbo-dynamos are undoubtedly light, compact and ingenious, and have their uses on board ship and elsewhere where these qualities are of primary importance, but they seem hardly suitable where the cost of coal is high and cost of floor space low.

Electric Light Mains and Systems of Distribution.—At the meeting of the Institute of Electrical Engineers, on Thursday evening last (the final meeting of the present session), a vigorous discussion arose on the three papers which had been read at the preceding meetings, namely, that of Dr. Fleming on "Some Effects of Alternating Current Flow in Circuits having Capacity and Self-Induction," and Mr. Preece's and Mr. Crompton's papers respectively on "Some Points Connected with Mains for Electric Lighting," and "The Most Economical Manner of Feeding a Low Tension Net Work." Among the speakers on Dr. Fleming's paper were Dr. Sumpner, Major Cardew, Messrs. Alexander Siemens, Blakesley and Swinburne. Mr. A. Siemens alluded briefly to some interesting experiments which had been carried out by his firm about a year ago and which had shown in a remarkable way the phenomenon of the piling up of the volts, where circuits having large electrostatic capacity and self-induction are employed, in connection with alternate currents. He made the interesting statement that the phenomenon seemed to be influenced by the type and shape of the transformer, disappearing entirely in one instance when an open circuit transformer was employed. Dr. Fleming, who had been somewhat severely handled for not mentioning the work of various investigators, replied briefly and to the point, remarking that whatever the short-comings of his paper might be, it had at least elicited an interesting and valuable discussion. The debate on Mr. Preece's and Mr. Crompton's papers was chiefly remarkable for Sir William Thomson's almost unqualified speech in favor of low-tension distribution. He was of opinion that next to nothing was gained *in the long run* by eccentric stations and pinned his faith on the future of what he called the Edison system, namely, a number of comparatively small mutually-supporting, low-tension stations situated as close as possible to the centres of the areas served by each one. He seemed to think that all the savings effected by going away from populous centres were more than balanced by losses in other directions. He thought that the only real point gained was the freedom from liability to injunctions for nuisances. Mr. Crompton's figures comparing the cost of mains on the high and low tension systems were severely criticised and completely upset by several speakers, amongst whom were Mr. Addenbrooke and Mr. Kapp. Altogether the debate was the most practical and instructive that the session has brought forth.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Ferranti Effect.—Will you kindly answer the following questions in your columns? (1) What is meant by the "Ferranti effect"? (2) What is the measurement of wire by circular mils? R. R. B.

(1) The "Ferranti effect" is the abnormal variation of potential observed in alternate current circuits of high pressure which have a high static capacity. It is really a condenser effect. (2) A mil is the one-thousandth part of an inch, and we get "circular mil" by squaring the diameter of a wire in mils. Thus a No. 36 wire has a diameter of five-thousandths of an inch, and its area in circular mils is 25.

Telephone Inductive Disturbance.—We have a metallic circuit telephone circuit of five miles, constructed with two wires to avoid disturbance from the electric railway line near by. We wish to run upon the same pole a second line for a grounded telephone circuit. Will we meet with induction in the new line?

F. C. M.

Most likely you will. We would advise the use of a metallic circuit for the second line. The proposed way is liable to so unbalance things as to cause a secondary disturbance in your first built line as well as in the second.

News of the Week.

THE TELEGRAPH.

North Dakota Extensions.—The Seaboard Air Line Company has completed its new telegraph line from Portsmouth to Charlotte as far as Hoffman. The work is being well done, and Charlotte will be reached some time in July.

Michigan Telegraph Improvements.—The Postal Telegraph Company has made a connection at North Escanaba with the Sioux line wires, and in future dispatches betwen Escanaba and Gladstone will not have to be sent via Sault Ste. Marie.

Superior, Wis.—The resolution authorizing the incorporation of the American District Telegraph Company passed the City Council last week, and all it needs is the signature of the mayor to insure the advent of the new company. It is not improbable that His Honor will veto the bill. Messrs. Butler & Catlin are the prime movers in the new enterprise.

Bicycles for Messengers.—The American District Telegraph Company and the Brooklyn District Telegraph Company are very active rivals in the Prospect Heights section of Brooklyn, N. Y. Last week Manager Welderman of the Brooklyn company stole a march on his competitor by purchasing four bicycles for the use of his messengers. The streets in that region are paved with asphalt, and the boys had a lively time answering calls during the week.

The Magellan Straits Cable.—The settlement of the Archipelago of Terra del Fuego, which until recently was considered a barren and useless territory, is so rapid and has progressed so far as to require telegraph facilities between the islands and the continent. The commander of the Argentine man-of-war Ushuaia has been directed to lay a cable between Cape Virgins and Espiritu Santo, which points are 22 miles apart. This is one of the wildest channels in the Straits of Magellan, but it is considered the safest and most convenient for cable communication.

Havana, Cuba.—Messrs. Vaslier and Mosquera, electrical engineers, have just installed in the telegraphic department of the Western Railway 50 Edison-Lalande battery cells of the "G" 300 ampère-hour type. The above railway is 120 miles in length and has along its route 22 telegraph stations. The galvanized iron line wire used is of No. 9 B. W. G. At either end is placed a battery of 15 of the above cells, the remaining cells being used along the line as local power. The work has been under the personal supervision of Mr. Vaslier.

B. & O. Tour of Inspection.—C. Selden, general superintendent of the Baltimore & Ohio Telegraph; T. Cannon, foreman of B. & O Telegraph; Dennis Dorin, general superintendent of the Western Union Telegraph Company, and W. P. Gill, superintendent of the Western Union, left Camden Station, Baltimore, this morning in a private car for a trip of inspection over all the lines of the B. & O. They will be away for a week or ten days. The various superintendents of construction of Western Union lines will meet Mr. Selden when he enters their district and remain with him until he leaves it. At Cumberland he was met by C. O Rowe and W. T. Barnard; at Parkersburg he will be met by I. N. Miller; at Belair O., by F. H. Tubbs, M. C. Bristol and A. Stevens.

THE TELEPHONE.

New Ohio Lines.—A project is on foot to connect Ooltewah, Cleveland, Dalton and Chattanooga by telephone.

Maryland Improvements.—The Chesapeake and Potomac Telephone Company last week began the work of rebuilding its lines at Hagerstown, Md.

Puyallup, Wash.—A large number of subscribers have signed contracts for telephones, and it is expected that the system will be installed at an early date.

Talmage, Neb.—The city's offer of $1,000 to be connected with neighboring towns by telephone has been accepted by the Nebraska Telephone Company, and the line will be built at once.

Fond du Lac, Wis.—Another large switchboard has been placed in the central office of the local Wisconsin Telephone Company, made necessary by the increasing list of subscribers.

New York State Lines.—The Empire State Telephone Company has finished putting up a telephone line on the east side of Lake Keuka, N. Y., connecting Penn Yan with Grove Spring and Keuka.

North Cambridge, Mass.—Fourteen of the telephone subscribers in North Cambridge propose ordering a discontinuance of the services unless the company will agree to reduce the price of the metallic circuit from $90 to $75.

New Pennsylvania Lines.—Work has been commenced on the new telephone line from Marion to Gettysburg. The work is under the supervision of Mr. J. A. Findley. A new line is also to be erected from Glen Campbell to Burnside.

New Jersey Lines.—The New Jersey Bell Telephone Company is running a long distance wire from the great Oak Ridge reservoir to Newark, via Paterson. It is now completed to the latter city. The lines will be connected with all the stations and reservoirs from Oak Ridge to Newark.

Cleveland, O.—The Cleveland Telephone Company is placing an underground cable in Euclid avenue as far as Erie street while that thoroughfare is being paved. The conduit used is earthenware, in short sections, which are cemented together with asphaltum, and wrapped with an indestructible cloth at the joints.

Oakland, Cal.—The Sunset Telegraph-Telephone Company is at present making some elaborate improvements in Oakland which will be greatly appreciated by a host of subscribers. The central office at the Masonic Temple building has been equipped with one of the latest patterns of the multiple switchboard, constructed by the Western Electric Company of Chicago, Ill.

THE ELECTRIC LIGHT.

Portland, Me., is to have a board of electrical control.

Waterville, Wash., is to have an electric light plant.

Healdsburg, Cal., is to be lighted by electricity next spring.

Versailles, Ky., is to pay $1,500 annually for fifteen arc lights for street lighting.

Middletown, Conn., has voted to adopt the electric light for street illumination.

Allegheny, Pa.—An official resolution is now before the City Council providing for the removal of the local arc light towers.

Badger, Wis.—The Badger Electric Company has been awarded the contract for lighting the city for a term of three years.

Indianapolis, Ind., is to pay $105 per light per annum next year. This is a higher rate than the preceding year. The contract is held with the Brush company.

Rosedale, Miss., Council has granted a franchise for a system of arc and incandescent lighting to a number of prominent citizens, and it is expected that the bids will soon be called for.

Beaver, Pa.—The Beaver Electric Arc Light Company, under the management of N. N. Davidson, received the contract for lighting the borough of New Brighton with 40 arc lights.

Joliet, Ill.—The new electric light plant, which is operated by water power, is now in successful working order and is giving the highest satisfaction. Six large turbine wheels are used.

Cincinnati, O.—Corporation Counsel Horstman, at the request of the Committee on Light, has prepared specifications upon which proposals will be invited for lighting the streets of the city by electricity.

Dillon, Mont.—Mr. J. H. Lawrence, proprietor of the Dillon Electric Light, Water and Power Company, is in Helena, Mont., perfecting his plans, and soon after his return work upon the plant will be begun.

Philadelphia, Pa.—As requested by Director Windrim, the Finance Committee last week directed the transfer of $17,376 from the annual appropriation for the Bureau of Lighting to be used for the extension of electric lights.

Cambridge, Mass.—The Cambridge Board of Aldermen last week authorized the Committee on Lamps to make a five-year contract with the Cambridge Electric Light Company for furnishing not less than 400 arc lights at $115 each per annum.

Stoughton, Wis.—Mr. J. S. Hutson is contemplating putting in an electric light plant for the purpose of lighting the city. He intends to get the power for the dynamo from the water power at Lyon's mill, at Dunkirk, and expects to run a cable from there to the city, a distance of three miles.

Woonsocket, R. I.—The Woonsocket Electric Machine and Power Company has taken a contract to light the Agricultural Park with electric arc lights. The grand stand, exhibition hall and lawns will be illuminated. Street cars will run to the grounds and the society proposes to erect a dancing pavilion at the park.

New York City.—Inspector James H. Davis, from the Supervising Architect's office at Washington, has been in New York City to examine the Post Office building and determine what alterations should be made in it. He will recommend, among other things, that the government put in steam heating and electric

lighting appliances, instead of paying outside parties for light and heat.

Hamilton, Wash.—The City Council last week granted an electric light franchise to J. L. Warner, under the terms of which the plant is to be begun within 90 days, and be completed and in full operation within six months from date. The town agrees to pay rental on 10 street lights, and all business houses will be supplied with incandescent lights. Application is in for an electric railway for the city.

Bath, N. Y.—At a special meeting of the Board of Trustees of the village of Bath, last week, the electric light question was finally settled, and a contract signed with the Bath Electric Light and Power Company. The contract provides for thirty-eight 2,000 c. p. arc lights, to burn from dusk until 1 A. M. 20 nights every month, for $66 per lamp per year, lights used over and above 20 nights a month to be furnished at 25 cents per lamp extra. The company also agrees to put in an incandescent plant. By the terms of the contract the plant must be located and ready for operation Sept. 25, and if not the company forfeits all of its rights under the contract. In case it is ready before that day, then the year for lighting begins from the time of such completion.

Brooklyn Navy Yard.—The plans for equipping the Navy Yard with an electric plant for lighting and other purposes have been completed, and bids for the furnishing of the plant are now open at Washington. The principal apparatus to be furnished are two compound wound dynamos of the most approved pattern for incandescent and arc-light circuits, complete, the dynamos to have a capacity of not less than 30,000 watts, 125 volts and 320 ampères; 37,000 feet of the best insulated weather-proof copper wire, 3,000 feet of standard insulated copper wire with fireproof braided cover, 3,000 feet of weatherproof and fireproof insulated copper wire, and 24,000 feet of No. 16 insulated copper wire; 250 spruce poles not less than 34 feet in length, 30 incandescent lamps of 32 c. p., 600 incandescent lamps of 16 c. p., and 36 double carbon 2,000 c. p. arc lamps of the latest pattern.

THE ELECTRIC RAILWAY.

Oldtown and Orono, Me., are to have an electric street railway under a consolidated organization of the separate companies of each town.

Winnipeg, Canada.—The Edison General Electric Company has recently closed a contract with the Winnipeg Street Railway Company for a 100 h. p. generator and four extra car equipments. It is expected that this plant will be in operation about June 10.

Detroit to Mt. Clemens, Mich.—F. E. Brookman, Fred Heide, Jr., D. McGuire, M. Thome and I. Shillington are interested in a project to build an electric road between Detroit and Mount Clemens, Mich. They have looked over the ground and think that it could be built for $200,000.

Nashville, Tenn.—The Nashville Power and Lighting Company is installing two 100 h. p. generators in its power house, and the Rapid Transit Company is increasing its capacity with a 150 h. p. dynamo. These companies have been in operation only a short time, but both are forced to increase their power. The former started with two 65 h. p. dynamos and the latter with a 75 h. p. The United Electric Company was compelled to increase its power soon after it began operations, in order to operate its cars successfully.

GENERAL APPLICATIONS OF POWER.

Electric Percussion Drill Plant.—The Edison General Electric Company has closed a contract with Hector McRae, of Ottawa, Canada, for an electric percussion drill and hoist for use in his phosphate mines in Templeton. The plant will probably be in use this month.

Electric Elevators in Boston Residences.—A number of fine residences in the Back Bay section of Boston are being equipped with elevators operated by electric motors. The machinery is very simple and compact, and the elevators will carry two or three persons at good speed.

Large Hoisting Plant in Cleveland, O.—At one of the city ore docks an electric hoisting apparatus, mounted upon a car traveling upon an overhead track, lifts 3,000 pounds of iron ore from the hold of a steamer and carries it 200 feet across the dock. The operator travels with the car and controls all of its movements.

Electric Elevators in New Albany, Ind.—The Gaynor Electric Light Company, of Louisville, Ky., is putting in two fine elevators in the agricultural warehouse of Messrs. B. Jollisant & Co. The work is under the supervision of Mr. R. P. Main, of Now Albany. The elevators, when completed, will cost $1,400, and are the first to be operated by electricity in the city.

Electrically Operated Drawbridge in Boston.—The draw on the new Harvard Bridge at Boston, Mass., will be operated by a six-horse electric motor instead of a steam engine, as was at first intended. Power will be furnished by the plant of the Brookline Gaslight Company. By using electricity as a motive power, the necessity of establishing an engine and boiler on the pier will be obviated, and a large sum annually will thus be saved. This is the only instance in the state where an electric motor has been bought for this purpose.

LEGAL NOTES.

Wants $10,000 for a Telephone Mistake.—F. E. Sloat, of Rochester, N. Y., has begun suit against the American Bell Telephone Company for $10,000, alleged damages for mistake in the sending by the company of a telephone message.

Williamsport, Pa., Electric Road.—Judge Metzger, at Williamsport, Pa., has refused the petition of the city to grant a preliminary injunction restraining the Lycoming Electric Light Company from erecting poles for the use of the Passenger Railway Company.

Might Be Contributory Negligence.—Mrs. Margaret Heffernan, an aged woman, has instituted suit against the New York & New Jersey Telephone Company for $10,000 damages for permanent injuries sustained by tripping over a coil of wire which had been left on the street by an employé of the company.

Small Judgments Against the Western Union.—Of late quite a number of small judgments for sums ranging from $1,000 to $5,000 have been decided against the Western Union Telegraph Company for delay or errors in transmitting messages. The most recent of these are: Dr. J. M. Neal, of Texas, $2,500, and Robert Dyer, of Texas, $1,000.

Saratoga (N. Y.) Electric Company vs. Hazard.—Judge Andrews, in the Supreme Court, at Saratoga, has decided the suit of the Saratoga Gas & Electric Light Company, of Saratoga Springs, against Rowland N. Hazard to recover for the conversion of 57 $1,000 bonds of its stock deposited with him as secretary of the suing company. The defense which Hazard made was that he sold the bonds by direction of the directors of the company. The verdict was in Hazard's favor.

The Subway War.—Judge Ingraham, in the New York Supreme Court Chambers, last week handed down a decision refusing to grant the injunction asked for by the Brush Electric Illuminating Company and other electric light companies restraining the Consolidated Telegraph and Electrical Subway Company from cutting the wires owned by the plaintiff companies and removing them from the subways. The light companies also wanted the court to fix an equitable rate for the use of the subways by the light companies. Judge Ingraham says that the Board of Electrical Control is the only body having power to fix the rate for the use of the sub ways.

Cincinnati Inclined Plane Railroad vs. Suburban Telegraph Company.—The Supreme Court of the State of Ohio has rendered a decision in the case of the Cincinnati Inclined Plane Railroad Company vs. the City and Suburban Telegraph Company. Action was brought by the telephone company to enjoin the railway company from the use of an electrical system of propulsion, upon the claim that that system interfered with the use of the telephone and almost destroyed its business; that the noise made by the railroad prevented one hearing when using the telephone, and the current from the railway circuit, being much the stronger, destroyed the current of the telephone lines. The court decided in favor of the railway company, upon the theory that the street is primarily intended for the use of the general public for traveling purposes, and the fact of motive power which facilitates travel being changed to something which might interfere with a subordinate use of the highway should not make any difference in that regard.

PERSONALS.

Mr. Henry Lewis, of New York City, has been appointed division superintendent of the Pennsylvania Telephone Company, with headquarters at Easton, Pa., to fill the vacancy occasioned by the recent promotion of W. J. Bampfield as general manager of the company.

Mr. George E. Hanson, who for a year has been the superintendent of the suburban offices of the Boston Division of the New England Telephone and Telegraph Company, retires from that position to assume general work in connection with the Boston office. The district which Mr. Hanson has covered is to be divided into two divisions, one with headquarters at Brookline, Mass., and the other with headquarters at Somerville, Mass. Mr. Reddington Fiske will be in charge of the former and Mr. I. O. Wright of the latter.

MISCELLANEOUS NOTES.

Scarce Electrical Books.—Very few of those who have never tried to procure out-of-print electrical books and periodicals are aware of their extreme scarcity. The early works of Sturgeon, for instance, can rarely be found on sale at any price, and are only to be obtained by leaving a standing order for them with a bookseller who makes a business of searching in every conceivable locality for such books as his customers may desire. The works of Ampère, Ohm, Faraday, Oersted, Galvani and Volta cannot be obtained in any other way than that mentioned above, unless the purchaser himself makes a business of searching for the works among the miscellaneous stock of second-hand booksellers and carefully watching the catalogues of auction book sales. The number of buyers for this class of books has very greatly increased in the last few years, owing no doubt to the greater interest taken in the development of the electrical industries. The early books and periodicals on electrical subjects published in America are noticeably scarce. The publications which contain much of the early history of the electric telegraph are seldom found on sale. Among these might be mentioned those of Vail, Henry, Morse, Amos Kendall, Jackson, O'Reilly, Gale, Hare, Davis, Shaffner, Prescott and others. Even publications of 10 years ago are now exceedingly scarce. This is especially true of publications in regard to electric lighting. So far as can be ascertained no library in this country possesses a complete set of early telegraph periodicals, which are now very valuable and will become more so in a few years.

Industrial and Trade Notes.

Mr. J. W. Mason, of 515 Main street, Kansas City, Mo., is meeting with success in introducing the safety insulated wires and electric light specialties to consumers in the Southwest.

Siemens Cables of the standard type are now manufactured in this country by the Edison General Electric Company at Schenectady, N. Y. The company has been licensed by Messrs. Siemens & Halske for the United States of America.

The Armington & Sims Engine Company, of Providence, R. I., has sent out a large number of finely engraved invitations to attend its exhibit of high-speed engines to be given at the time of the June meeting of the American Society of Mechanical Engineers and of the Master Car Builders' Association at Providence.

Changes in the Russell Electrical Manufacturing Company.—It is announced that Mr. John I. Drake has withdrawn from active interest in the company, and that hereafter the business will be conducted by Chas. W. Russell and John Heathcote. The company now has large facilities for the manufacture of its specialties, and will be able to turn out a large amount of excellent work.

The Electric Merchandise Company, of 11 Adams street, Chicago, Ill., has issued a beautifully engraved card announcing its first anniversary. This company is the only concern engaged exclusively in the electrical railway supply business, and, although a new firm, the members of the company have all been engaged for several years in the sphere of electrical railway engineering and commercial enterprise.

The Swinging Ball Lightning Arrester is now placed upon the market by Messrs. Truex & Vail, of 136 Liberty street, New York City. This is one of the latest designs of lightning arrester before the public. It has no fuses, and requires scarcely any attention. It is well protected from moisture, and has no electromagnets or complicated parts. A number of excellent testimonies have been secured by the company from users of this instrument.

Messrs. Partrick & Carter, of Philadelphia, have issued the following notice to the trade: "We desire to inform you that we have arranged a general Canadian agency with the Toronto Construction and Electrical Supply Company, of Toronto, Ont., who will carry in stock annunciators, alarms, bells, pushes, batteries, etc., etc., of our manufacture. This arrangement has been made for the convenience of the trade in general, at points far distant from Philadelphia, who desire to use our goods more extensively, but have been deterred from doing so owing to the excessive charges for transportation and delay in transit."

The Tropical American Telephone Company, of Boston, has just been awarded the gold medal for its "Tropical" telephone sets, both for long distance and for commercial uses, at the Jamaica Exposition. These sets are manufactured for it abroad, and are especially adapted for its export trade in tropical countries. Great care is taken to guard against corrosion of the exposed parts. The contacts are pointed with platinum and the workmanship is first class in every respect. These export sets are sold outright, it is said, at prices under those formerly paid the American Bell Telephone Company for its ordinary telephone sets, and many testimonials to their excellence are being received from its customers in South America and West Indies.

The Pettingell-Andrews Company, of 192-202 Summer street, Boston, has issued the following announcement: "We beg to announce that having purchased the entire business of the Standard Electric Supply Company, No. 180 Summer street, Boston, Mass., we shall be pleased to serve the wants of all its former customers, not only for all varieties of electric light, power and railway supplies, but also for the various specialties heretofore handled by it. Our facilities are most complete for filling orders of all sizes at the shortest notice, and it shall be our constant endeavor, by prompt service, low prices and courteous treatment, to merit not only a continuance of the patronage of our old customers but a share of the business of those whom we have not before had the pleasure of serving."

Messrs. Milliken Bros., New York city and Chicago, report a large increase and demand for their patent poles for electric street railway and electric light use. They have lately booked orders for a large number of poles for the Pittsfield Electric Light Company, a new form of combination pole for both street railway and electric light wires. They have also received orders for Los Angeles, Cal.; Little Rock, Ark.; St. Louis, Mo.; Plainfield, N. J., and Brooklyn. Parties in Wilmington, Del., have found it to their advantage to use poles somewhat similar to the large ones which this concern lately furnished to Passaic, N. J., and which are known as the largest street railway poles in the world. The arms for these poles are only a trifle shorter than the poles supplied to Passaic. Parties desiring a first-class pole for street railway work cannot do better than write to these parties for their handsomely illustrated catalogue, which gives full information. They are furnishing a large number of poles to South American countries, and report business very brisk.

The Charles Munson Belting Company has supplied, as was noticed in the last issue of THE ELECTRICAL WORLD, a 72-inch belt, 150 feet long, to the Missouri Street Railway Company, of St. Louis, for use in an extension of its plant. This belt, however, weighs 3,000 pounds instead of the much lower figure given in the note alluded to. Those acquainted with the character of the work turned out by this company are well aware that a belt of this size would not be put into service unless carefully designed and built for the work it was intended to do. As a matter of fact the belt is one of the largest ever built, and the large number of interested parties who have seen it on exhibition unite in saying that it is an admirable piece of work. The Munson company has formerly supplied two 54-inch belts for the same company, and this 72-inch one is for transmitting 2,000 h. p. It is belted to a pulley 108 inches in diameter with a 78-inch face and weighing 14,000 pounds. The tightener pulley is 60 inches in diameter, has an 80-inch face and weighs 5,000 pounds. The work was designed and laid out by the Hill Clutch Works, of Cleveland, O.

The Purity Oil Filter Manufacturing Company, 107 First avenue, Pittsburgh, Pa., has recently placed its apparatus in use with the following concerns, and in every instance it has given excellent satisfaction: Westinghouse Electric and Manufacturing Company, Pittsburgh; National Electric Tramway and Lighting Company, of Victoria, British Columbia; Mount Morris Electric Light Company, New York; Manhattan Electric Light Company, New York; Waltham Gas Light Company, Waltham, Mass.; Edison Electric Illuminating Company, Boston, Mass.; Ross Park Street Railway, Spokane Falls, Wash.; Ottumwa Electric Railway and Steam Company, Ottumwa, Ia.; Citizen's Traction Company, Pittsburgh; Powell Electric Company, Philadelphia, Pa.; Evansville Gas and Electric Light Company, Evansville, Ind.; Chaudiere Electric Light and Power Company, Ottawa, Canada; Citizens' Gas Light and Heating Company, Bloomington, Ill.; Utica Belt Street Railway, Utica, N. Y.; Electric Light and Power Company, Terre Haute, Ind.; Westinghouse Brake Company, Wilmerding, Pa.; Cincinnati Electric Light and Power Company, Cincinnati, O.

The Buckeye Electric Company, of Cleveland, O., has recently placed an incandescent lamp on the market, the making of the filament for which is an interesting process. The organic material from which the filament is prepared passes under heavy pressure from its glass container through tubes having minute orifices into a precipitating liquid, where the gelatinous thread thus formed coils itself in small rings. These coils are then taken from the receiving jars and washed in special fluids that dissolve out any foreign matter that may accidentally be associated with the compounds, and are then wound on drums and exposed to the air, which absorbs the moisture, leaving a glossy, firm, transparent thread. This is then wound on solid blocks of carbon, which are placed in plumbago-covered crucibles, that are subjected to a temperature equivalent to the melting point of steel, converting the thread into a dense, homogeneous filament of remarkable hardness. This filament is then cut into standard lengths, and after a careful measurement of its exact diameter is connected to the platinum wires previously prepared, a slight pressure of the forceps closing the platinum to the thread, where it is securely sealed in a petroleum bath, after being short circuited about half an inch above the platinum, the necessary current depositing a layer of carbon on the platinum and the lower end of the filament. Being securely fastened in its socket, the next step is to send it to the glass-blowing room. High-grade glass bulbs are secured already blown, and after having the small tip formed are passed to the next glass worker, who trims the lower end of the bulb to the proper length, and then, placing the filament within the bulb, seals the platinum wires in position. Six glass bulbs are then fused on to as many glass tubes projecting from a central tube or fork, which is then fused directly on to the exhaust pump. This is a modified form of Geissler pump, having no open joints, all connections being made by fusing the glass, thus insuring complete exhaustion. The lamps are left on the pump for 90 minutes, when the small opening at the top is sealed by fusing, and the lamp then carried to the dark room, where it is tested by means of an induction spark. The lamps are then kept in circuit on the testing rack for an hour, then passed to the photometer room, and, on careful measuring, are passed out to be capped, again placed in circuit on the testing rack, and later on packed in suitable containers. In

caps used are of superior finish, and contain porcelain whenever an insulating material is used.

Business Notices.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren street, Syracuse, N. Y.

Summer and Autumn Resorts.—The most charming summer resorts, of which there are over three hundred choice locations, are to be found in Wisconsin, Iowa, Minnesota, South Dakota, and the Peninsula of Michigan, along the lines of the Chicago, Milwaukee & St. Paul Railway. Nearly all are located near lakes which have not been fished out. These resorts are easily reached by railway, and range in variety from the "full dress for dinner" to the flannel-shirt costume for every meal. The finest shooting grounds in the Northwest are on and tributary to the lines of the Chicago, Milwaukee & St. Paul Railway. The crop of prairie chickens will be exceptionally good this year; also ducks and geese. In northern Wisconsin and the Peninsula of Michigan splendid deer shooting is to be had. Full information furnished free. Address Geo. H. Heafford, general passenger agent, Chicago, Ill.

The Easton Electric Company, main office 45 Broadway, New York City, factory Brooklyn, N. Y., is the manufacturer of the celebrated Easton arc dynamos, new Universal arc lamps for arc and incandescent circuits adapted to any dynamo, Easton incandescent dynamos, generators, motors, etc. Plants are installed at Rockland, Me.; Elmira, N. Y.; Lynchburg, Va.; Newark, N. J.; Brooklyn, N. Y.; Denver, Col.; Chicago, Ill.; Milwaukee, Wis.; Burlington, Ia.; Reading, Pa.; Birmingham, Ala.; Milledgeville, Ga.; Washington, D. C.; Coney Island, N. Y.; Whitehall, N. Y.; Eureka, Kan.; Lee, Mass., and Lakeland, Fla. Testimonials and indorsements of the highest character furnished on application. This company is now prepared to enter into an arrangement of a favorable character with a reliable and satisfactory concern who will undertake the exclusive sale of the entire output of the factory for the United States. Correspondence invited.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENT ISSUED MAY 5, 1891.

451,885. Method of Constructing Field Magnets of Electric Motors: Schuyler S. Wheeler, of New York, N. Y., Assignor to the Crocker-Wheeler Electric Motor Co., of same place. Application filed September 13, 1890. The method of forming field magnets of electric motors or dynamo-electric machines which consists in boring the yoke or base and trimming the ends of the field forgings with reference to the centre of their concave parts so that when assembled the cylindrical ends of the field forgings will fit into the borings in the yoke or base and the parts form a true cylindrical space for the armature.

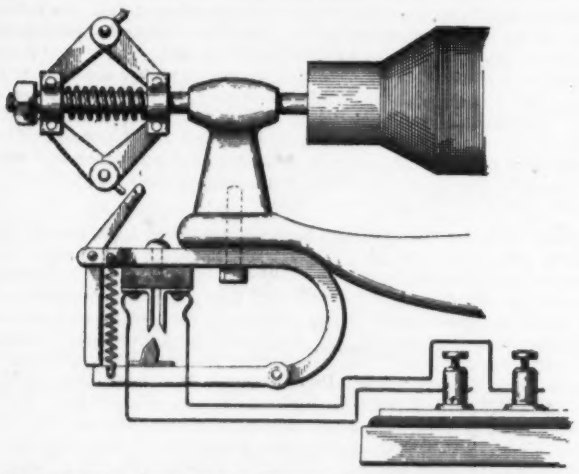
U. S. PATENTS ISSUED JUNE 2, 1891.

453,216. Electric Street Car Motor; Jabez F. Shawhan, of Dayton, O., Assignor by mesne assignments to Freeman B. Dickerson, of Detroit, Mich. Application filed Sept. 9, 1889. A motor car having a rigid truck frame connecting rigidly the two axles, and a second frame supported by spring bearings upon the truck frame and connected with the body, and an electromotor arranged upon the truck frame with independent connections between the motor and the different wheels, and batteries mounted upon the spring-supported frame.

453,225. Electric Connector; Frank Wheeler, of Meriden, Conn. Application filed Dec. 30, 1890. An electric connector consisting of a pair of duplicate parts, each of said parts having a semi-tubular projection and a semi-annular recess, and a flat contact of spring material, rigidly secured at one end to the terminal of the conductor, and having its other end bent at an angle in the other direction. (See illustration.)

453,242. Magnetic Electric Machine; William Humans, of Cambridge, Mass., Assignor to the American Magnetic Electric Co., of Jersey City, N. J. Application filed July 23, 1885. The combination of the shaft carrying an armature and the armature coils, with a case having a hole through it, in which the armature and the armature coils are rotated, and provided with lids which when shut confine the armature and its coils in the hole in the case and when open allow the armature and its coils to be rotated.

453,248. Bracket for Electric Lamps; Thomas Carpenter Smith of Philadelphia, Pa. Application filed May 19, 1890. A



No. 453,287.—AUTOMATIC SWITCH FOR ELECTRIC MOTORS.

bracket provided with two pair of arms, each at right angles to the other, one pair angular and adapted to receive the conductor insulators, the other pair provided with screwhooks adapted to receive the insulators upon which the shuntbox is fastened.

453,260. Electric Magnetic Engine; Charles Edmund Kells, Jr., of New Orleans, La. Application filed Feb. 24, 1891. The combination of an electric motor, a driving wheel or pulley, and an electromagnetic clutch in series with the field-coils of the motor and with a circuit breaker, whereby the stopping and starting of the motor and the release or engagement of the clutch coincide.

453,261. Telegraph Receiver; Charles Langdon Davies, of London, England, Assignor to The Phonopore Syndicate, Limited, of same place. Application filed Nov. 18, 1890. In a telegraph receiver a coil receiving vibratory impulses from a line wire and thereby varying the magnetism of a permanently magnetized core and causing the same intermittently to attract an armature on a strained metallic ribbon in combination with the re-enforcing coils, the circuit of which is opened as the ribbon oscillates and which also affect the magnetization of the permanently magnetized core.

453,281. Safety Device for Dynamos; Charles Griffith Young, of New York, N. Y. Application filed March 31, 1890. In a system of electrical distribution the combination of an electric generator, a main line in circuit therewith, and a cut-out in circuit with said generator and controlled by a device in continuous circuit with said main line and the ground.

453,287. Automatic Switch for Electric Motors; Roderick Macrae, of Baltimore, Md., Assignor to the Donaldson-Macrae Electric Co., of same place. Application filed Aug. 27, 1890. The invention consisting of an armature having toggle levers on its shaft, and a spring-actuated lever and contact points so arranged that at a predetermined speed the toggles operate to short circuit the poles of the motor. (See illustration.)

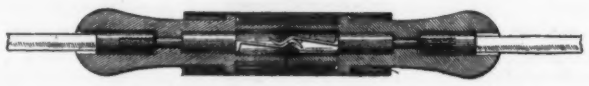
453,317. Method of Magnetic Separation; Henry C. Townsend, of New York, N. Y. Application filed Sept. 27, 1890. The method of separating magnetic from non-magnetic material, consisting in establishing a flow of liquid in which said materials are carried in divided form, producing in the liquid stream two flowing strata, in one of which the magnetic material is maintained by magnetic action opposed to another force, as gravity, by which the non-magnetic materials are forced or maintained in another stratum, and diverting the stratum of flowing liquid and magnetic material through a channel separate from that through which the stratum holding the non-magnetic material passes. (See illustration.)

453,318, 453,319. Automatic Starting Switch for Electric Motors; Ferdinand A. Wessell, of Brooklyn, Assignor to the Excelsior Electric Co., of New York, N. Y. Application filed Jan. 9, 1891. The invention consists of an electric motor, of an armature for the same normally out of central or neutral position in the magnetic field, and a rheostatic switch placed in the armature circuit and operated or controlled by the end movement of the armature shaft due to the centring tendency of the field magnet when the motor is thrown into operation.

453,320. Automatic Starting Switch for Electric Motors; Ferdinand A. Wessell, of Brooklyn, Assignor to the Excelsior Electric Co., of New York, N. Y. Application filed Jan. 9, 1891. The invention consists of an electric motor fed from constant-potential mains and a rheostatic switch, the whole or greater part of whose resistance is included in the armature circuit when the motor is at rest and running at slow speed, said resistance being independent of the field magnet and in a separate branch with the armature of the motor, an armature or keeper placed within the influence of the field magnet and connected to the rheostatic switch, and a retarding device.

453,323. Electric-Current Tester; Wm. H. Ebert, of New York, N. Y., Assignor of one-half to John C. Beekman, of same place. Application filed Feb. 20, 1891. A testing device, comprising a voltaic pair permanently connected by a yoke, and a pair of flexible conductors, one for each member of the pair, fixed in electric contact therewith.

453,326. Insulating Cover for Trolley or Conducting Wires for Electric Railways; Albert L. Ide, of Springfield, Ill. Application filed Dec. 31, 1890. A trolley or conducting wire



No. 453,225.—ELECTRIC CONNECTOR.

partially enveloped in a non-conducting insulating covering suitably applied thereto, said covering being thickest in cross-section at its central portion.

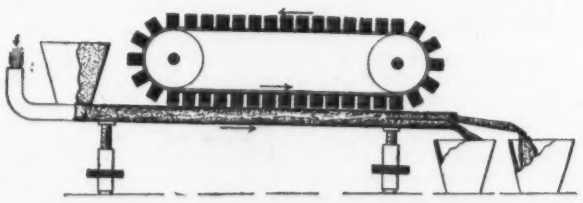
453,337. Detachable Rosette; Charles E. Davis, of Chicago, Ill. Application filed Dec. 31, 1890. In a detachable rosette, two flat springs arranged to spring laterally, each being supported at or near one end to the edge of one element of the body of the rosette, and protruding toward the interior thereof substantially parallel to each other, and upright flat contacts mounted upon the other element and adapted to engage the interior surfaces of the springs by being inserted between them and turned until they meet contact surfaces of the spring, in combination with laterally projecting portions upon the upright contacts adapted to protrude outwardly above the springs when the contact surfaces engage.

453,349. Switchboard for Electric Arc-Light Stations; Robert F. Sawyer, of Chicago, Ill. Application filed Oct. 23, 1890. In a switchboard a line-circuit terminal consisting of a right-hand terminal for the positive and for the negative pole of the line circuit and of a left-hand terminal for each of such poles, a pivoted lever electrically connected at its pivoted point with the positive wire of the line circuit, and a second pivoted lever electrically connected at its pivotal point with the negative wire of the line circuit, such levers being coupled together so that the movement of one thereof will produce movement in the other thereof, but such levers not electrically connected, in combination with a dynamo-circuit terminal and transfer plugs electrically connected in pairs, each of such transfer plugs being adapted to be electrically connected with the dynamo-circuit terminals and the line-circuit terminals.

453,355. Process of Coating Metals with Oxides; Alexander Elliot Haswell and Arthur George Haswell, of Vienna, Austria-Hungary. Application filed Nov. 3, 1890. The process of electro-depositing binoxide of lead on iron and steel, which consists in immersing the article to be coated in a bath containing nitrate of lead and nitrate of ammonia in solution, and in depositing binoxide of lead from such bath by passing an electric current through the said bath.

453,367. Starting Switch for Electric Motors; Clark C. Haskins, of Chicago, Ill. Application filed Oct. 24, 1890. In combination with a rheostat switch, a pivotal switch finger, controlled by a spring to return automatically to the off point from any contact to which it is turned therefrom, a bridge yieldingly supported to extend over the contacts and normally obstructing the return upon the contacts of the said finger, and catch for retaining the finger in opposition to its said spring at the terminal contact.

453,416. Electric Annunciator System; Louis M. Pinoler, of Brooklyn, N. Y. Application filed Sept. 25, 1890. In an electric annunciator system, the combination of rotating concentric discs rotating together but independently movable, circuit-closers at different points, as in the rooms of a hotel, an electromagnet



No. 453,317.—METHOD OF MAGNETIC SEPARATION.

in circuit with each push button and provided with an armature, and two projections upon each of said discs at different distances from the centre, the said armatures being so located that any attracted armature lies in the path of one said projection, and an electric generator in circuit with said magnets and said push buttons, indicating numerals being upon said discs.

453,433. Holder for Telephone Receivers; Frank Tiffin Tinning and William Kerr Sumner Tinning, of Toronto, Canada, Assignor of one-fifth to Charles Warren Irwin, of same place. Application filed March 5, 1891. The bracket having a friction disc formed on its end, in combination with a second friction disc, and a cord connected at one end to the telephone hook and at the other end to a thumb screw.

453,447. Railway Signaling Device; William Alfred Luby, of Kalamazoo, Mich. Application filed Nov. 26, 1890. A semaphore having a signal arm and incandescent electric signal lights, said arm being actuated by a suitable electro-magnetic device, in combination with a railroad commutating switch and track annunciator, suitable electric circuits provided with circuit controllers for automatically opening and closing them, connecting the annunciator with the electro-magnetic device for actuating the signal-arm and the incandescent lights, said annunciator being electrically connected with the railroad track and switches, so that it will indicate the position of switches and the presence of cars upon the track so connected, whereby danger and safety signals will be automatically displayed on the approach of a train.

453,455. Electric Lamp Socket; Le Roy S. White, of Waterbury, Conn., Assignor to the Electrical Appliance Manufacturing Company, of same place. Application filed April 1, 1891. A socket for electric lamps, comprising a frame or casing, contact plates for closing and breaking the circuit, binding posts for the attachments of the wires, a screw and a key, the said contact plates and binding posts being secured to the end of the socket frame or casing by the binding screw.

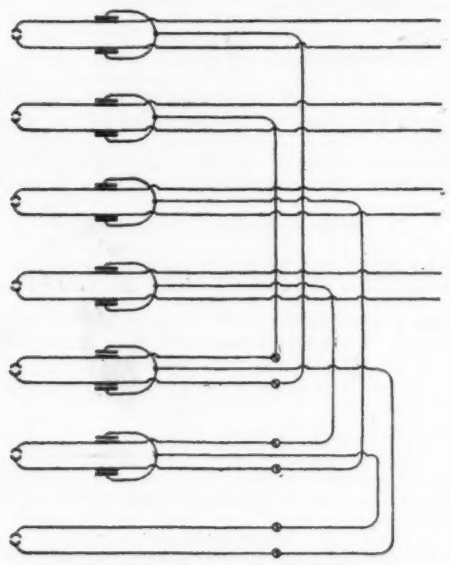
453,466. Circuit Closer for Burglar Alarms; Edwin A. Darling, of Hopedale, Mass., Assignor of one-half to William F. Draper, of same place. Application filed Jan. 10, 1888. A circuit closer composed of two thin, flat elastic strips of conducting materials and a number of thin pads of insulating materials interposed between said conducting strips at short distances from one another along the said conductors, and a tubular covering inclosing the said springs.

453,476. Electrical Apparatus for Surgical Purposes; Cornelius Bennett Harness, of London, England. Application filed Jan. 26, 1891. Providing for the treatment of patients preparatory to and during surgical and dental operations by first causing an electric current to pass through the body of the patient between any two parts thereof, and then changing the path of the current so that it will pass through the patient's body between one or both of the said parts to be operated upon.

453,483. Telephone Circuit; Wm. W. Jacques, of Newton, Assignor to the American Bell Telephone Co., of Boston, Mass. Application filed March 7, 1891. The invention comprises two pairs of condensers, one pair for each circuit, and one plate of a separate condenser in contact with each line-wire. The opposite or free plates of the pair of the condensers of each circuit are connected by a metallic loop, and the two loops thus formed are connected by a third. (See illustration.)

453,572. Automatic Electric Switch; Robert Baumann, of St. Louis, Mo., Assignor to the Electric Alarm Lock Company, of same place. Application filed Nov. 7, 1890. In an electric switch, a conducting strip, having its central portion secured to the periphery thereof and having its end bent outward, and connecting plates adapted to be connected to the opposite poles of electric circuit and to make simultaneous contact with the outwardly extending ends of the said strip.

453,578. Electric Railroad Signal Alarm; Newton S. Chapman, of Kansas City, Mo., Assignor of one-half to Frank



No. 453,483.—TELEPHONE CIRCUIT.

Hagerman, of same place. Application filed Feb. 18, 1891. In an electric railroad signal alarm, a series of locomotive engines, each provided with an electric generator, alarm, insulated metallic brushes, and testing brushes suspended from the yoke of the engines, which are operated by suitable arms and levers.

453,581. Telephone Transmitter; Philip Fitzsimons, of Birmingham, Ala., Assignor of one-half to Frederick Hardy, of same place. Application filed September 9, 1890. In a telephone transmitter having terminals of the bell circuit, primary and secondary wires of the induction coil respectively, a plate forming the terminal of the battery and having a spring which is adapted to make electrical connection with one of the metal conductors and a transverse pin projecting within the path of the spring.

453,583. Electric Arc Lamp; William Hochhausen, of Brooklyn, Assignor to the Excelsior Electric Co., of New York, N. Y. Application filed May 28, 1890. An electric arc lamp having a perforated plate of iron constituting the armature of a magnet and mounted and sustained upon fixed pivotal bearings to one side of the vertical line, in which the carbon feed, a ring-clutch sustained loosely on said armature and having an opening coincident with the perforation in the armature, and an electromagnet beneath said armature for drawing the same down to effect a release of the clutch.

453,597. System of Electrical Distribution; Frederick A. La Roche, of Philadelphia, Pa., Assignor to the La Roche Electric Works. Application filed May 17, 1890. An electric circuit having two generating sources of substantially equal electromotive force, a lead connecting electrically the positive poles of said sources, a lead connecting electrically the negative poles of said sources, and translating devices electrically connected between said leads at various points.

453,600. Mechanical Telephone; John P. Sunderland, of Brooklyn, Assignor to Domingo M. Monjo, trustee, of New York, N.Y. Application filed Sept. 22, 1888. A mechanical telephone having a diaphragm, a spindle projecting to the rear thereof, a line-wire connected to said spindle and passing rearwardly through a loop, thence sidewise at an angle and through a second loop, and thence through the spindle and along the line.

453,601. Sextuplex Telegraph; Thomas A. Edison, of Menlo Park, N. J., Assignor to the Western Union Telegraph Company, of New York, N. Y. Application filed June 2, 1877. The invention involves the arrangement of electro-magnets and circuit connections in which one responds to reversals in the direction of the flow of the current in the line and the other two sets of devices to an increase or decrease in the strength of the current independent of its direction.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.